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U.S. Coast Guard

Removal Action Work Plan



Old Station Ludington Ludington, Michigan

April 2009

Prepared for

**U.S. Coast Guard
Civil Engineering Unit Cleveland**

Prepared by



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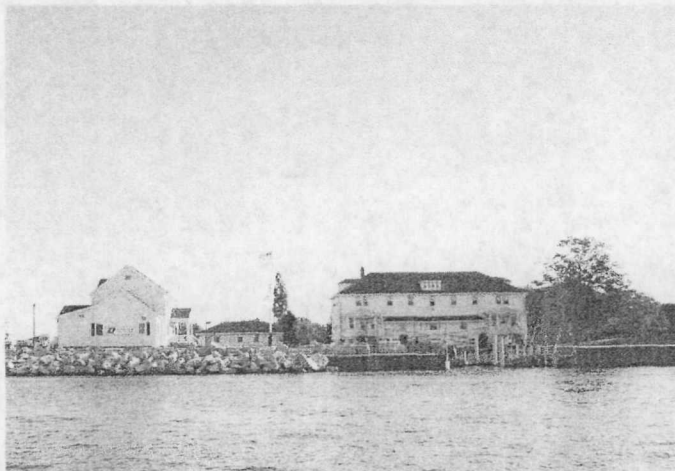


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Ludington, Michigan**

April 3, 2009



ARCADIS

U.S. Department of
Homeland Security

United States
Coast Guard



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1. Introduction

This removal action work plan (RAWP) was prepared by ARCADIS on behalf of the United States Coast Guard (USCG) for the eastern portion of the USCG Station Ludington, known as Old Station Ludington (Site) located in Ludington, Michigan (see Figure 1 and Figure 2). This RAWP was prepared in accordance with United States Environmental Protection Agency (USEPA) Guidance for Conducting Non-Time-Critical Removal Actions Under CERCLA [Comprehensive Environmental Response, Compensation and Liability Act] and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Code of Federal Regulations (40 CFR) Part 300 Section 300.415, to address soil impacted by lead at concentrations above site-specific removal action objectives (RAOs) resulting from the historical application and weathering of lead-based paint on the Site structures.

Site characterization activities included the collection of soil samples, installation of three groundwater monitoring wells, and collection of groundwater samples from the monitoring wells. Results of the soil sampling activities that are presented in the Engineering Evaluation/Cost Analysis (EE/CA) (ARCADIS U.S., Inc. 2009) indicated that lead impacts are present in near-surface soil above the RAO of 400 milligrams per kilogram (mg/kg). Based on field screening and laboratory analytical results for vertical delineation samples, lead-impacted soil above the RAO does not extend below 1 foot below ground surface (bgs) at the Site.

As part of the removal site evaluation, three monitoring wells were installed and three quarterly groundwater sampling events were completed (August 2008, November 2008 and February 2009) as described in the Field Sampling Plan (FSP) (ARCADIS U.S., Inc. 2008a) and the EE/CA (ARCADIS U.S., Inc. 2009). One additional quarterly sampling event will be performed in May 2009. Results of the completed groundwater sampling events are presented in the EE/CA and indicate that there are no lead impacts to groundwater at the Site. If reported groundwater concentrations continue to be below state and federal criteria, the monitoring wells will be abandoned following analysis of the fourth quarter samples. Removal of soil impacts to the RAO will prevent any potential future migration of lead in soil to groundwater. Therefore, no groundwater remediation will be necessary for the Site prior to conveyance of the property from the federal inventory. This RAWP is designed to be used in conjunction with other supporting documents, including the FSP (ARCADIS U.S., Inc. 2008a), EE/CA (ARCADIS U.S., Inc. 2009), and the Site-specific Quality Assurance Project Plan (QAPP) (ARCADIS U.S., Inc. 2008b). Because the removal action will require field

screening and collecting removal confirmation soil samples, this RAWP also contains some of the prescribed elements of a FSP consistent with Section 300.410 of the NCP.

Additional information relevant to this RAWP provided in the EE/CA includes the following:

- Site description and background information
- Source, nature, and extent of contamination and waste characterization
- Streamlined risk evaluation
- Applicable or relevant and appropriate requirements (ARARs)
- RAOs
- Identification of removal action alternatives and selection of removal action as the anticipated final remedy

Additional information relevant to this RAWP provided in the QAPP includes the following:

- Project management and objectives
- Measurement and data acquisition
- Assessment and oversight
- Data review
- Chain-of-Custody forms
- Laboratory Quality Assurance Plans and Standard Operating Procedures (SOPs)
- Laboratory Certifications

Additional information relevant to the RAWP provided in the FSP includes the following:

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- Sample designation system
- Quality Assurance/Quality Control (QA/QC) procedures

2. Plan for Removal Action

The primary objective of the proposed removal action is to protect public health, welfare, and the environment, thereby facilitating conveyance of the Site from the federal inventory to the City of Ludington (City) for public use (e.g., park or museum). It is the intent of USCG to conduct all response actions in a manner consistent with the NCP and Section 120 of CERCLA. As indicated in the EE/CA (ARCADIS U.S., Inc. 2009), the only constituent of concern (COC) identified at the Site is lead in soil. As discussed in the EE/CA, the USCG has selected an RAO for lead in soil at the Site of 400 mg/kg. The anticipated future use of the Site is recreational. The Site will be used for public purposes. There are currently no identified soil cleanup objectives more protective of human health and the environment than the residential land-use screening level of 400 mg/kg. The USCG has selected the residential land-use screening level of 400 mg/kg as the Site-specific RAO and intends to implement a removal action for the soil impacted by lead above the RAO in accordance with Sections 300.410 and 300.415 of the NCP prior to conveyance of the Site.

The RAO for soil cleanup is expected to be protective of relevant exposure pathways for the current and anticipated future land use for the Site. The residual lead in soil at concentrations above the RAO has been defined horizontally and vertically at the Site as detailed in Section 2.2 of the EE/CA and summarized as follows.

Results of the removal site evaluation conducted by ARCADIS in August 2008 indicated that surface/near-surface soils located primarily on the eastern and northeastern portions of the Site and one smaller impacted area near the southwestern corner of the Old Station Building have been impacted by lead-based paint from the external building surfaces. Soil impacts from the lead-based paint are limited to the upper 1 foot of soil (see Figure 3). This is consistent with the conceptual site model, which indicates that the soil lead impacts are derived from weathering of historically applied lead-based paint from the external surfaces of the Site structures. No other potential sources of soil or groundwater contamination have been identified at the Site.

As discussed in the EE/CA, chemical-specific, location-specific, and action-specific federal statutes and regulations that are applicable or relevant and appropriate to the planned removal action are identified in Table 1a, Table 1b, and Table 1c, respectively. Consistent with Section 430 (d) (3) of the NCP, the USCG requested that the Michigan Department of Environmental Quality (MDEQ) identify potential state ARARs for the Site in a letter dated September 25, 2008. A copy of this letter is included in the EE/CA. As of the date of this RAWP, a response from the MDEQ regarding the identification of

state ARARs has not been received. Therefore, ARCADIS and the USCG have evaluated, and included herein, potential State of Michigan requirements based on professional judgment consistent with other sites in Michigan where similar removal actions have been performed. In addition, chemical-specific, location-specific, and action-specific federal and state guidelines identified as to be considered (TBC) are also presented in Table 1a, Table 1b, and Table 1c. Soil removal activities will be performed in accordance with the identified ARARs and with consideration to the TBC guidance as described in the following sections. The USCG intends to proceed with the proposed removal action as planned, consistent with provisions of the NCP.

2.1 Soil Removal Activities

Based on the limited depth and extent of soil impacts, the USCG has determined that the most cost-effective and protective remedy for the Site is removal and off-site disposal of lead-impacted soil above the RAO of 400 mg/kg. Soils with lead impacts exceeding the RAO are shown on Figure 3. Removal and off-site disposal of lead-impacted soil above the RAO is consistent with Section 300.415 (b) (2) of the NCP and state requirements for protecting public health, welfare, and the environment by:

- Preventing risk of human exposure through dermal contact, ingestion, or inhalation of lead-impacted soil during future use of the Site or potential construction activities on-site.
- Preventing risks due to potential future migration of lead from soils to groundwater or surface water at concentrations above generic MDEQ drinking water (DW) or Groundwater/Surface-Water Interface (GSI) screening levels (Michigan Department of Environmental Quality 2006).

The following is a detailed description of the proposed soil removal actions for the Site.

2.1.1 Site Access

No access agreements will be required because the federal government is the current owner of the Site, and removal activities are not expected to encroach on adjacent properties. Portions of the removal action will take place in proximity to a City manhole. The City will receive a copy of the EE/CA and this RAWP before the removal action is implemented for their files. No other notifications or access requirements are envisioned.

2.1.2 Site Preparation

The areas targeted for the proposed soil removal are identified on Figure 4. Prior to beginning the soil removal action, the extent of each excavation will be measured and marked with stakes and survey tape. Work zones and staging areas for vehicles and equipment will be marked accordingly prior to beginning removal activities. Construction safety fence will be set up along the south, east, and north sides of the Site to keep bystanders out of the work zones. Dump trucks or roll-off boxes designated to transport the removed soil to the landfill will enter the Site through the driveway on the north side of the Old Station Building. The soil will be directly loaded into the dump truck or roll-off box from the front-end loader or excavator. A decontamination station for equipment and vehicles will also be established in the parking lot on the north side of the Old Station Building.

2.1.2.1 Utility Clearance

The one-call utility location service, Miss Dig System, Inc. will be contacted at least three working days prior to the removal activities. Available Site plans provided by the USCG will be consulted to identify any existing utilities at the Site (see Figure 2). A geophysical survey was performed in August 2008 by Geosphere, Inc. The survey investigated the Site, as well as the active USCG Station west of the Site, for potential buried tanks and piping and other utilities. No potential obstructions, piping, or utilities were identified by the geophysical survey within the proposed removal areas. A record of the utility location procedures will be maintained by the oversight contractor for the project files. The planned soil removal actions will proceed only when all utility clearance actions are complete and documented. As an added precaution, hand digging will be performed in areas immediately adjacent to the building to avoid damaging the building or potential unknown utilities.

2.1.2.2 Historic Preservation

In accordance with Section 106 of the National Historic Preservation Act (NHPA) and current Michigan State Historic Preservation Office (SHPO) guidelines, the USCG contracted the completion of a Cultural Resource Survey for the Site prior to performing the Site characterization activities. Results of the Cultural Resource Survey indicated that the proposed activities would have no effect on significant cultural or historic resources. The associated report and plans for the removal action were submitted to the SHPO for review on September 25, 2008 to determine if the planned

soil removal activities could affect culturally or historically significant resources, if present at the Site.

The USCG subsequently received a letter from the SHPO dated January 15, 2009 stating that the proposed removal activities would not adversely affect the Old Station Ludington and that the USCG is in compliance with Section 106 of the NHPA. Results of the Cultural Resources Survey and evaluation by the SHPO are described in detail in the EE/CA (ARCADIS U.S., Inc. 2009).

2.1.2.3 Endangered Species Act

The Site consists of the Old Station Building, a small grassy lawn area east of the building, and landscaped areas. The remainder of the Site is covered by pavement (e.g., driveways, sidewalks, and concrete pier) (see Figure 2). Due to the lack of suitable habitat at the Site, the USCG determined that Site characterization and removal action activities were not likely to adversely affect threatened or endangered species or habitat. Further, the proposed soil removal action primarily includes areas adjacent to the building, with minor disturbance of the lawn area east of the building. Therefore, the proposed removal action is not likely to adversely affect threatened or endangered species.

2.1.2.4 Soil Erosion and Sedimentation Control

Due to the proximity of the Site to the Pere Marquette River, a Soil Erosion and Sedimentation Control (SESC) Plan has been prepared in accordance with Part 91 of the Natural Resources and Environmental Protection Act of Michigan. The SESC plan has been prepared to describe the soil erosion and sedimentation control measures that will be implemented at the Site throughout the removal action. The SESC Plan and SESC measures are consistent with guidance provided in the 2005 MDEQ Water Bureau Soil Erosion and Sedimentation Control Program, Soil Erosion and Sedimentation Training Manual (MDEQ 2005). The SESC Plan is provided in Appendix A, and includes (1) the installation of silt fencing along the edge of Site or paved areas to prevent erosion and transport of eroded soil and (2) the installation of filter fabric in on-site and nearby storm drain catch basins.

Removal activities will be completed in a way that minimizes the potential for erosion and transport of soil from the removal areas to the adjacent surface-water bodies or nearby catch basins. During the soil excavation, the contractor will excavate the impacted soil and place the soil directly into a truck or staged roll-off, reducing or

eliminating the need for stockpiling. However in the event that direct loading of impacted soil and unloading of fill soil cannot be achieved, soil stockpiles will be constructed on plastic sheeting, and covered with plastic sheeting to prevent erosion.

All SESC measures will be maintained throughout the removal action in accordance with the SESC guidance. Following completion of the soil removal and restoration of the Site, the temporary SESC measures will be removed.

2.1.3 Site Restriction and Security

It is anticipated that throughout the removal activities pedestrians will be present along the public sidewalk located south of the work zone along the Pere Marquette River and potentially on the residential property located to the east of the Site (see Figure 2). Pedestrians present in these areas will be separated from the work area by construction safety fencing. In the event bystanders are observed approaching work areas or equipment, the oversight contractor will immediately stop work and ask the bystanders to move out of the work area. This will be done for the safety of potential bystanders, as well as work crews. Construction safety fence will be used throughout the removal action and Site restoration bordering the work area to prevent bystanders from approaching (see Figure 4).

2.1.4 Soil Removal

Soil impacted with lead at concentrations above the RAO will be excavated and transported to an appropriately licensed and screened landfill within the State of Michigan for disposal. A local or nearby landfill will be selected based on availability and pricing to minimize the over-road travel of the waste soil. Site characterization sampling indicates that the lead impacts at concentrations above the RAO are confined to the near-surface soils approximately 0 to 1 foot bgs, and within approximately 0 to 50 feet of the existing structures (see Figure 3). During excavation, soil will be removed in approximately 1-foot increments to the total targeted depth (i.e., 1 foot bgs) in the areas of identified impact. The locations of proposed soil excavations at the Site are illustrated on Figure 4.

Based on the Site characterization sampling summarized in Section 3 of the EE/CA and on Figure 3 of this RAWP, up to 60 cubic yards of non-hazardous soil will be excavated and removed from the Site. The soils to be removed contain reported lead concentrations of 370 mg/kg to 1,200 mg/kg. The extents of proposed non-hazardous soil excavations are depicted on Figure 4. The removal areas depicted on Figure 4 are

based on the available Site characterization data presented in the EE/CA. The estimated removal volume of 60 cubic yards is based on the assumption that some over-excavation will be needed based on field screening and confirmatory sample results. If the initial field screening and removal confirmation samples indicate the RAO has been achieved with no over-excavation, the total soil volume removed will be less than 60 cubic yards.

Soils removed from these areas will be directly loaded into trucks or roll-off boxes staged at the Site and transported in accordance with Department of Transportation (DOT) regulations to the appropriately licensed landfill within the State of Michigan for disposal as non-hazardous soil. Clean fill soil will be brought to the Site for backfilling the excavations. Certification of periodic testing of the fill soil will be obtained from the soil provider. In addition, at least one composite sample of the backfill soil will be analyzed for lead by USEPA Method 6010B to evaluate lead concentration in the fill soil prior to being placed in the excavations.

Based on the anticipated limited depth of the removal activities (i.e., 1 foot bgs), compaction of the soil backfill is not anticipated to be necessary. If the excavations exceed 1 foot to 2 feet in depth, manual compaction or compaction with a vibratory compactor may be employed to prevent settling.

To minimize the potential for damaging the Old Station Building exterior, extreme care will be taken in performing the impacted soil removal actions. Soil removal will be performed utilizing hand tools (e.g., spades or shovels) directly adjacent to the Old Station Building to prevent damage to the external building surface. Soil removal away from the Old Station Building will be performed using a small excavator, backhoe, or front-end loader. Because the soil removal is expected to extend only to 1 foot bgs, potential undermining of the structure is not anticipated to be a concern.

2.1.4.1 Field Screening

To guide the effective and complete removal of soil impacted by lead at concentrations above the RAO, the removal oversight contractor will conduct field screening of soil using an Innov-X Alpha Series X-ray fluorescence (XRF) analyzer or equivalent. This model unit does not require radioisotope operator certification as it operates using a low power (1.0 watt [W]) excitation source consisting of an X-Ray tube with a silver (Ag) anode target. However, the instrument will be registered with the Michigan Department of Community Health Radiation Safety Section prior to use at the Site.

After the anticipated volume of impacted soil has been removed at each location, soil samples will be collected from the excavation bottom and each of the sidewalls for XRF analysis to define the extent of the excavations. Soil samples will be field screened according to the USEPA Method 6200 *Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment* provided in Appendix B.

The portion of soil selected for field screening will be prepared by placing approximately 8 ounces of soil into a disposable zip-locking plastic bag. Any large pieces of soil within the plastic bag will be broken into smaller pieces, and the soil will be blended to form as homogeneous a mixture as is practical. The bagged samples will be placed on a lead-free plastic work table prior to XRF screening. Each sample will be screened by placing the XRF analyzer onto the sample for 30 seconds to obtain comparable results among the samples. A copy of the Innov-X Alpha Series instruments specification sheet is included in Appendix C.

The XRF analyzer will be calibrated daily according to the Site QAPP and calibration results recorded in the field notes or on equipment calibration logs. XRF analyzer results will be recorded in the field notes or on field data sheets in instrument units that are equivalent to parts per million (ppm, roughly equivalent to mg/kg) along with the measurement error (+/-) of the instrument. If field screening indicates lead concentrations at or above 300 mg/kg, additional soil will be removed. The soil removal will be terminated at each location when results of the field screening indicate lead concentrations lower than 300 mg/kg. Once the soil removal is complete, confirmation soil samples will be collected to verify removal of impacted soil to the RAO. If the laboratory analysis indicates that a confirmatory sample exceeds the RAO, additional excavation will be necessary to remove the associated soils. After the reexcavation is complete, the area will be resampled and field screened, and additional samples submitted for laboratory analyses to verify that the RAO is met. The sampling will be conducted according to the procedures presented in Section 2.2, and laboratory analysis will be performed in accordance with the QAPP (ARCADIS U.S., Inc. 2008b).

2.1.4.2 Cultural Artifacts

Based on the results of the Cultural Resources Survey and correspondence with the SHPO, it is not anticipated that historically or culturally significant artifacts will be unearthed during the soil removal action. However, in the event that objects of potential historical or cultural significance are encountered, the excavation oversight contractor will stop the removal action and contact the USCG and the SHPO to discuss the

findings. A field determination will be made based on discussions between the involved parties as to the significance of the findings. Prior to proceeding with the additional soil removal activities, concurrence will be obtained from the SHPO that the additional removal activities will not adversely affect the historical or cultural significance of the Site.

If the extent of excavations is significantly increased based on field screening results beyond what was submitted to the SHPO, the SHPO will be contacted for further consultation prior to proceeding with the soil removal action.

2.1.4.3 Soil Transport and Disposal Management

The impacted soil will be live-loaded into trucks or roll-off boxes staged at the Site during the removal action to minimize the need for stockpiling soils. All non-hazardous waste will be sent to a local or nearby disposal facility within the State of Michigan. Non-hazardous waste soils will be transported by the removal contractor to an approved landfill for disposal. An appropriate landfill will be selected based on availability and pricing to minimize the over-road travel of the waste soils. Trucks are not required to be placarded, and drums are not required to be labeled. The trucks will follow a prescribed transportation route to the approved disposal facility.

The USCG will review, approve, and sign all waste profiles and non-hazardous waste shipping documents prior to the shipment of soil from the Site. The oversight contractor, ARCADIS, will obtain weight tickets, tare/gross weight slips, and non-hazardous waste shipping documents from each truckload of non-hazardous waste soil transported from the Site. The volume of material removed from the Site will be recorded in the field notes in accordance with the QAPP. Certificates of disposal will be obtained from the disposal facilities. Copies of all transport and disposal documentation will be provided in the removal action completion report and will be kept on file as part of the administrative record by the USCG as long as is appropriate.

2.1.5 Shoring and Dewatering

Because the excavations are not expected to exceed 1 foot to 2 feet bgs, no shoring or dewatering measures are anticipated to be needed. Groundwater was identified at approximately 5 feet bgs in monitoring wells installed at the Site (ARCADIS U.S., Inc. 2009). Therefore, excavation dewatering is not anticipated to be required.

2.1.6 Air Monitoring

Air monitoring will be performed and documented throughout the entire soil removal action because of the potential for inhalation exposure to dust containing particulate lead. Air quality will be continuously monitored with a particulate meter within the work zone according to the Health and Safety Plan (HASP) provided in Appendix D, using a particulate meter to monitor worker exposure to airborne particulate concentrations. One or more air monitoring stations will also be established on the downwind perimeter of the active work zone to ensure protection of workers and others (e.g., property users, occupants, or adjacent land owners) outside the work zone and to assess the potential for dust mobilization during the removal efforts.

Air quality will be continuously monitored at temporary air monitoring stations, and measurements of total particulate concentration, as well as date, time, and wind direction, will be recorded on air monitoring logs or in the field notes. The location and frequency of temporary individual monitoring stations will depend on the activities being conducted and the predominant wind direction. If the action levels identified in the HASP are exceeded, the oversight contractor will immediately stop work and establish a plan for reducing the dust emissions at the Site.

2.1.7 Dust Suppression

Based on the shallow depths of the proposed excavations (0 to 1 foot bgs) and the limited lateral extent of these excavations, dust problems are not anticipated during soil removal activities. However, if the action levels defined in the HASP (Appendix D) are exceeded at any time, work will be stopped, and dust suppression measures will be evaluated. These measures may include, but are not limited to, spraying the excavations lightly with clean water to minimize dust emissions.

2.2 Confirmation Sampling

Removal confirmation samples will be collected following the soil removal action using the "biased" sampling approach. There are five discrete excavations (two small landscaped areas adjacent to the southwestern staircase have been combined). Confirmation sidewall and bottom samples will be collected from each discrete excavation. Removal area bottom samples and sidewall samples will be collected after the anticipated depth and lateral extent of each excavation is reached.

Bottom samples will be collected based on a biased sampling approach at a minimum frequency of approximately two samples per 1,000 square feet of excavation footprint, with a minimum of two bottom samples per discrete excavation. Sidewall samples will be collected at a minimum frequency of approximately one sample per 25 linear feet of sidewall, with a minimum of one sample per sidewall (total of at least four sidewall samples per discrete excavation). Sidewall samples will not be collected from the sidewalls of excavations that are located adjacent to the Old Station Ludington Building foundation. Soil removal will be performed in these areas until the foundation is exposed so there will be no soil remaining to collect sidewall samples from. Field screening will be performed at the bottom of the excavation adjacent to the foundation, and additional bottom samples will be collected from the excavation bottoms, immediately adjacent to the foundation if warranted by the field screening (i.e., results greater than 300 mg/kg).

Removal confirmation bottom and sidewall samples will be biased toward locations that contained the highest reported lead concentrations within each excavation during Site characterization activities (ARCADIS U.S., Inc. 2009) and based on results of the XRF field screening during removal activities. Approximately 32 confirmation samples are anticipated to be collected.

The depths and lateral extents of soil removal areas will be determined by results of the field screening. Bottom and sidewall samples will first be field screened using the XRF analyzer as described above in Section 2.1.4.1. If XRF field screening results indicate potential residual impacts (i.e., results greater than 300 mg/kg), additional soil will be removed and subsequent bottom and sidewall samples collected as described above. If results of the field screening are lower than 300 mg/kg, the samples will be sent to the laboratory for confirmatory analysis.

Confirmation samples will be collected in laboratory-provided containers using a decontaminated stainless-steel scoop or shovel according to the SOP for *Soil Sample Collection and Handling* provided in Appendix B and the QAPP (ARCADIS U.S., Inc. 2008b). Sample containers will be labeled with the sample location identification, date of sample collection, and intended analysis. Sample nomenclature will be consistent with the nomenclature from previous Site characterization activities and is described in detail in Section 7.2 of the FSP (ARCADIS U.S., Inc. 2008a). The samples will be immediately placed on ice in a cooler awaiting transport to the laboratory by courier.

Samples will be submitted to TestAmerica Analytical Testing Corporation (TestAmerica) located in Watertown, Wisconsin for analysis of fine and coarse fraction

lead in accordance with MDEQ SOP number 213 and USEPA Method 6010B. Method 6010B analysis is being performed rather than Method 7420 as described in the QAPP because the contract laboratory no longer maintains the equipment for Method 7420. A QAPP Addendum will be prepared and submitted to the USEPA prior to the removal action, including the laboratory SOPs and relevant worksheets to reflect the USEPA Method 6010B analysis for soil and 6020A analysis for water (e.g., blanks and groundwater samples). Laboratory results for soil will be reported on a dry-weight basis for total, fine, and coarse fractions as described in the QAPP. Chain-of-custody protocol will be documented and strictly adhered to in accordance with the QAPP. Appropriate QA/QC samples will be collected in accordance with the QAPP for the Site. Full contract laboratory program (CLP)-type (Level 3) analytical reporting and validation will be requested for all removal confirmation samples collected from excavation sidewalls and bottoms as described in the QAPP (ARCADIS U.S., Inc. 2008b).

Based on the limited depth and extent of impacted soil above the RAO, approximately 32 confirmation samples are expected to be collected to demonstrate effective and complete removal of impacted soil at concentrations above the RAO. If the excavations are expanded based on field screening results, the appropriate number of confirmation samples will be recalculated in accordance with the approach described above based on the size of each excavation, and additional confirmation samples will be collected as appropriate.

2.3 Decontamination Procedures

Equipment in contact with the impacted soil or a significant amount of dust will be decontaminated according to the SOP provided in Appendix B. Reusable equipment used for soil sampling will be scrubbed using a solution of detergent and distilled water and double-rinsed in distilled water. Decontamination water will be containerized in an appropriately labeled DOT-approved 55-gallon drum, and a composite sample of the contents will be collected for waste characterization analysis as described in the QAPP (ARCADIS U.S., Inc. 2008b). The drum will be securely sealed and appropriately labeled, and remain at the work Site pending receipt of laboratory results upon which the waste will be properly disposed at an appropriately licensed nearby facility.

2.4 Site Restoration

The excavation will be backfilled to approximately 3 inches bgs with fill soil, and the remaining 3 inches will be backfilled with topsoil. Based on the estimated volume of soil

to be removed from the Site, up to 60 cubic yards of clean soil will be used to regrade the areas of excavation. In the lawn areas that were previously grass covered before the removal, the topsoil will be covered with grass seed and straw mats to revegetate the ground surface to pre-excavation condition and prevent erosion. Grass seed similar to the species currently growing at the Site will be used if possible to preserve the integrity of the Site. If necessary, additional grass seed will be placed at locations outside the excavation areas to repair grass that was disrupted by removal activities. Every effort will be made to minimize disturbance to unimpacted areas of the Site during removal. For the locations surrounding the building that were previously covered with landscape rock, a similar rock type will be used to cover the fill soil. Following stabilization of the ground surface, all temporary SESC measures will be removed.

2.5 Site Survey

The final excavation limits and locations of confirmation samples will be surveyed using traditional survey techniques as defined in the SOP provided in Appendix B. The names and locations of survey points will also be recorded in the field notes. The survey data will be used to update the Site figures following the removal action and to prepare the Removal Action Completion Report.

3. Contractor Selection

ARCADIS will serve as the oversight contractor for the soil removal action. Qualified subcontractors for the excavation, transport, and disposal of soil and laboratory analysis for this project have been identified based on predetermined qualifications. Sufficient resources are available for the timely and cost-effective implementation of this RAWP. A project organizational chart and contact information for project personnel are provided in the QAPP.

4. Documentation and Report Preparation

The oversight contractor, ARCADIS, will oversee the removal action subcontractor, perform the confirmation sampling activities, and document these activities. The documentation will include equipment calibration forms, confirmation sample data, chain-of-custody forms, manifests, dimensions of the soil excavations, volumes of soil removed, sampling and analytical procedures, and excavation procedures. Site activities will be recorded in the field notes and on appropriate log forms as needed. Photographic documentation of the removal action and confirmation sampling will also be performed by the oversight contractor. Upon completion of the removal action and confirmation sampling activities, the oversight contractor will prepare a Removal Action Completion Report.

5. Schedule

The USCG received a letter from USEPA dated March 30, 2009 indicating USEPA concurrence with the actions taken by the USCG, including this RAWP and recommending that the RAWP be finalized. Therefore the USCG intends to proceed with the proposed soil removal action as planned. A copy of the letter from USEPA is included in Appendix E. The EE/CA and the RAWP will be made available for public review for a period of 30 days. The USCG will provide a response to all substantive comments received from the public or the State. It is the goal of the USCG to complete the removal action during summer 2009. A project schedule is provided in Table 2.

6. References

- ARCADIS U.S., Inc. 2008a. *Field Sampling Plan. United States Coast Guard Old Station Ludington, Ludington, Michigan.* September 2008.
- ARCADIS U.S., Inc. 2008b. *Quality Assurance Project Plan. United States Coast Guard Old Station Ludington, Ludington, Michigan.* August 2008.
- ARCADIS U.S., Inc. 2009. *Engineering Evaluation/Cost Analysis. United States Coast Guard Old Station Ludington, Ludington, Michigan.* April 2009.
- Commonwealth Cultural Resources Group, Inc. *Phase I Cultural Resource Assessment, Ludington Life Saving Station, Mason County, Michigan.* September 2008.
- Comprehensive Environmental Response, Compensation, and Liability Act, December 11, 1980 as amended by Superfund Amendments and Reauthorization Act of October 17, 1986.
- Michigan Department of Environmental Quality. 2005. Water Bureau Soil Erosion and Sedimentation Control Program, *Soil Erosion and Sedimentation Control Training Manual.* November 2005.
- Michigan Department of Environmental Quality. 2006. *Operational Memorandum No. 1. Table 2. Soil: Residential and Commercial I Part 201 Generic Cleanup Criteria and Part 213 Tier 1 Risk-Based Screening Levels.* January 23, 2006.
- National Historic Preservation Act of 1966, as amended.
- United States Environmental Protection Agency. 1993. *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA.* EPA540-R-93-057. August 1993.
- United States Environmental Protection Agency. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Method 6200, Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment,* February 2007.

TABLES

Table 1a. Federal and State Chemical-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance, U.S. Coast Guard, Old Station Ludington, Ludington, Michigan.

Constituent of Concern and Media	Authority	Act	Statute, Regulation, Administrative Code, or Guidance Document	Status	Synopsis of Requirement, Criteria, or Guidance
Lead in Soil	Federal Regulatory Requirement and/or Criteria	NA	NA	NA	Because the site is intended for recreational use, there are no Applicable or Relevant and Appropriate Criteria.
	Federal Advisories, Guidance, and Training Material	NA	Revised Interim Soil Lead Guidance for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Sites and Resource Conservation and Recovery Act (RCRA) Corrective Action Facilities, OSWER Directive #9355.4-12 (United States Environmental Protection Agency 1994) OSWER Directive 9355.4-12 Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, OSWER Directive 9200.4-27P (United States Environmental Protection Agency 1998) Clarification Memo	To Be Considered	These documents are non-promulgated guidance to be used as guidelines for evaluating site investigation data. Describes how to develop site-specific Preliminary Remediation Goals (PRGs) at CERCLA Sites and Media Cleanup Standards (MCSs) at RCRA Corrective Action facilities for residential land use. They describe a plan for soil lead cleanup at CERCLA sites and RCRA Corrective Action facilities that have multiple sources of lead. The recommended Screening Level for Lead in Soil is 400 milligrams per kilogram (mg/kg) for generic residential land use (assumes bare soil in child's play area as the exposure scenario).
	State Requirements and/or Criteria	Natural Resources Environmental and Protection Act of 1994, Public Act 451 as amended (NREPA)	Michigan Compiled Law 324, Part 201, Michigan Administrative Code (MAC) Rules 299.5706, 299.5707, 299.5718 through 299.5726, 299.5732, 299.5746, 299.5748, 299.5750, and 299.5752 MAC Rules for Part 201	Relevant and Appropriate*	These are promulgated statutes and rules associated with cleanup criteria. See Tables 2 and 3 in the MAC Rules for Generic Criteria and Screening Levels for each land use category. Generic Criteria for Lead in soil are: <ul style="list-style-type: none">Residential and Commercial I, Commercial III, and Commercial IV = 400 mg/kgRecreational = NA (use Rule 299.5732 for site-specific criterion calculation)Commercial II = 900 mg/kgDrinking Water Protection = 700 mg/kgGroundwater/Surface-Water Interface Protection = Varies depending on pH and hardness of receiving water (see footnote G in R299.5750) Alternatively, development of a site-specific limited criterion for lead is allowed by Rule 299.5732 and is calculated based on site-specific exposure pathway evaluation, exposure controls measures, and land-use considerations.
	State Advisories, Guidance, and Training Material	NA	Michigan Department of Environmental Quality (MDEQ) Remediation and Redevelopment Divisions (RRD) Operational Memorandum Number 1 (Part 201 Cleanup Criteria) MDEQ RRD Op Memo 1	To Be Considered*	This document is a non-promulgated memorandum prepared by the MDEQ to provide guidance on satisfying the cleanup criteria requirements under NREPA Part 201; it defines land-use categories and provides updated and interim cleanup criteria and screening levels. The attachments to the operational memorandum provide technical support documentation for the chemical physical data and algorithms used to calculate the criteria.
		NA	MDEQ RRD Operational Memorandum Number 2 (Part 201 Sampling and Analysis Guidance) MDEQ RRD Op Memo 2	To Be Considered*	This document is a non-promulgated memorandum prepared by the MDEQ to provide guidance on target detection limits and designated analytical methods; soil leaching methods; sample preservation; sampling, handling, and holding times; and the collection of samples for comparison to generic Criteria
	Federal Regulatory Requirement and/or Criteria	Clean Air Act (CAA)	42 USC 7409 42 USC 7409 40 CFR 50.12 and Appendix G to Part 50 40 CFR 50.12 Appendix G to Part 50	Applicable	These rules establish emissions limits for lead and describe test methods and procedures to determine emissions. The national primary and secondary ambient air quality standards for lead and its compounds, measured as elemental lead by a reference method based on Appendix G to 40 CFR 50, or by an equivalent method, are 1.5 micrograms per cubic meter (µg/m³), maximum arithmetic mean averaged over a calendar quarter.
	Federal Advisories, Guidance, and Training Material	None	None	None	None
Lead in Air	State Regulatory Requirement and/or Criteria	NA	Michigan Air Pollution Control Rules Part 2. Air Use Approval Exemptions R336.1290 Part 2 Air Use Approval Exemptions	Applicable*	Establishes exemption from permit to install for emission units with limited emissions. Establishes thresholds and limits by pollutant type and recordkeeping requirements.
	State Advisories and Guidance	None	None	None	None

See notes on page 2.

Table 1a. Federal and State Chemical-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance, U.S. Coast Guard, Old Station Ludington, Ludington, Michigan.

Constituent of Concern and Media	Authority	Act	Statute, Regulation, Administrative Code, or Guidance Document	Status	Synopsis of Requirement, Criteria, or Guidance
Lead in Water	Federal Regulatory Requirement and/or Criteria	NA	NA	NA	Groundwater is not impacted above any Applicable or Relevant and Appropriate Criteria.
	Federal Advisories, Guidance, and Training Material	NA	NA	NA	Groundwater is not impacted above any Applicable or Relevant and Appropriate Criteria.
	State Regulatory Requirement	NREPA, Act 451 of 1994	Michigan Compiled Laws Chapter 324, Part 201 MAC Rules, Groundwater Cleanup Criteria R299.5706, R299.5708, R299.5709, R299.5710, R299.5712, R299.5716, R299.5730, R299.5732, and R299.5744 MAC Part 201 Rules	NA	Groundwater and surface water are not impacted above any Applicable or Relevant and Appropriate Criteria.
		NA	MAC Rules Water Resources Protection (Part 31, Section 324.3109) MAC Part 31 Rules	NA	Groundwater and surface water are not impacted above any Applicable or Relevant and Appropriate Criteria.
	State Advisories, Guidance, and Training Material	NA	RRD Operational Memorandum Number 1 (Part 201 Cleanup Criteria) MDEQ RRD Op Memo 1	NA	Groundwater and surface water are not impacted above any Applicable or Relevant and Appropriate Criteria.
		NA	MDEQ RRD Operational Memorandum Number 2 (Part 201 Sampling and Analysis Guidance) MDEQ RRD Op Memo 2	NA	Groundwater and surface water are not impacted above any Applicable or Relevant and Appropriate Criteria.
		NA	MDEQ RRD Operational Memorandum Number 5 (Part 201 Groundwater/Surface-Water Pathway Criteria) MDEQ RRD Op Memo 5	NA	Groundwater and surface water are not impacted above any Applicable or Relevant and Appropriate Criteria.

Notes:
TBD To Be Determined.
NA Not Applicable.
* The USCG solicited Applicable or Relevant and Appropriate Requirements (ARARs) from the State of Michigan in a letter dated September 25, 2008. A response from the MDEQ has not been received.
Potential State of Michigan ARARs and To Be Considered (TBCs) have been evaluated based on professional judgment consistent with other Sites in Michigan, where similar removal actions have been performed.

Table 1b. Location-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance, U.S. Coast Guard, Old Station Ludington, Ludington, Michigan.

Location	Authority	Act	Statute, Regulation, Administrative Code, or Guidance Document	Status	Synopsis of Requirement, Criteria, or Guidance
Federally Owned Property	Federal Regulatory Requirement	National Historic Preservation Act of 1966	National Historic Preservation 16 USC 470 USC 16 Section 470 Protection of Historic Properties (36 CFR 800) 36 CFR 800	Applicable	These rules require the identification and preservation of historic and archaeological sites. The act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices. Among other things, the act requires federal agencies to evaluate the impact of all federally funded or permitted projects through a process known as a Section 106 Review.
	Federal Advisories, Guidance, and Training Material	None	None	None	None
	State Regulatory Requirement and/or Criteria	None	None	None	None
	State Advisories, Guidance, and Training Material	None	None	None	None

Notes:
TBD To Be Determined.
NA Not Applicable.
* The USCG solicited Applicable or Relevant and Appropriate Requirements (ARARs) from the State of Michigan in a letter dated September 25, 2008. A response from the MDEQ has not been received.
Potential State of Michigan ARARs and To Be Considered (TBCs) have been evaluated based on professional judgment consistent with other Sites in Michigan, where similar removal actions have been performed.

Table 1c. Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance, U.S. Coast Guard, Old Station Ludington, Ludington, Michigan.

Action	Authority	Act or Statute	Regulation, Administrative Code, or Guidance Document	Status	Synopsis
Excavation of Lead Impacted Soil	Federal Regulatory Requirement	Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as amended by the 1986 Superfund Amendments and Reauthorization Act (SARA)	Federal Facilities 42 United States Code (USC) 9620 42 USC 9620 Reporting Hazardous Substance Activity When Selling or Transferring Federal Real Property (Title 40 Code of Federal Regulations [CFR] 373) 40 CFR 373	Applicable	These rules require notifications related to hazardous substances prior to the sale or transfer of real property owned by the federal government. This is applicable if a property with residual contamination is transferred.
		CERCLA as amended by the 1986 SARA	National Contingency Plan (42 USC 9605) 42 USC 9605 National Contingency Plan (40 CFR Section 300.400 through 300.415) 40 CFR 300	Applicable	These promulgated rules require performing a Removal Site Evaluation and a Removal Action including preparing certain documents (Quality Assurance Project Plan [QAPP], a field sampling plan [FSP], and an engineering evaluation cost analysis [EE/CA]), considering federal and state ARARs, soliciting community involvement and providing notifications prior to the removal action.
		Executive Order 12580 of January 23, 1987, Superfund Implementation	Executive Order 12580- Superfund Implementation Executive Order 12580	Applicable	The Executive Order provides federal agencies, including the United States Coast Guard, the authority to carry out their CERLCA responsibilities under the National Contingency Plan as a lead agency.
		Occupational Safety & Health Administration Act (OSHA) of 1970	Occupational Safety & Health Administration Act (Public Law 91-596 84 STAT. 1590) PL 91-596 OSHA Occupational Safety & Health Administration (29 CFR 1910) 29 CFR 1910	Applicable	These regulations specify requirements for health and safety protection for workers exposed to contaminants during hazardous waste site remediation.
		OSHA	Occupational Safety & Health Administration Act (Public Law 91-596 84 STAT. 1590) PL 91-596 OSHA ACT Occupational Safety & Health Administration (29 CFR 1926) 29 CFR 1926	Applicable	These regulations specify requirements for health and safety protection for workers at construction sites.
	State Regulatory Requirement	Natural Resources Environmental Protection Act of 1994, Public Act 451 as amended (NREPA)	Soil Conservation, Erosion, and Sedimentation Control Part 91 Michigan Administrative Code (MAC) R323.1702(1), R323.1709 (2), R323.1709 (3), R323.1709 (4), R323.1709 (5) Part 91	Relevant and Appropriate*	These regulations specify requirements for earth change actions including erosion and sedimentation control measures that will effectively reduce accelerated soil erosion and resulting sedimentation. These regulations require the construction of temporary or permanent control measures to remove sediment from run-off water before it leaves the site.
		NREPA	Michigan Compiled Law 324, Part 55 Section 324.5524 Air Pollution Control MCL 324 Part 55 MAC Air Pollution Control Rules 336.1370 through 336.1374 Michigan Air Pollution Control Rules	Relevant and Appropriate*	These promulgated statutes and rules are associated with fugitive dust emissions.
	Federal Advisories and Guidance	None	None	None	None.

See notes on page 5.

Table 1c. Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance, U.S. Coast Guard, Old Station Ludington, Ludington, Michigan.

Action	Authority	Act or Statute	Regulation, Administrative Code, or Guidance Document	Status	Synopsis
Excavation of Lead Impacted Soil (continued)	State Advisories and Guidance	NA	Michigan Department of Environmental Quality (MDEQ) Sampling Strategies and Statistical Training Materials for Part 201 Clean up Criteria (S3TM) S3TM Guidance	To Be Considered*	This document includes non-promulgated training materials prepared by the MDEQ to provide recommendations on sampling of environmental media for various sampling objectives under NREPA Part 201, determine when it is appropriate to use statistics, and identify which statistical methods to use for comparing data to Part 201 cleanup criteria.
		NA	MDEQ Water Bureau Soil Erosion and Sedimentation (SES) Control Program, Soil Erosion and Sedimentation Training Manual SES Training Manual	To Be Considered*	This document includes non-promulgated guidance material prepared to assist in the design and construction of erosion and sedimentation control measures.
		NA	MDEQ Remediation and Redevelopment Division (RRD) Operational Memorandum Number 2 (Part 201 Sampling and Analysis Guidance) MDEQ RRD Op Memo 2	To Be Considered*	This document is a non-promulgated memorandum prepared by the MDEQ to provide guidance on target detection limits and designated analytical methods; soil leaching methods; sample preservation, sampling, and handling and holding times; and the collection of samples for comparison to generic criteria.
			MDEQ RRD Operational Memorandum Number 4 (Site Characterization and Remediation Verification) MDEQ RRD Op Memo 4	To Be Considered*	This document is a non-promulgated memorandum prepared by the MDEQ to provide direction for generating data for facility characterization (nature, extent, and impact of a release or threat of a release) and monitoring to support remedial decisions and assessing exposure pathways for compliance with cleanup criteria. The sampling strategies identified in this document represent acceptable approaches and ranges of appropriate assumptions that are intended to support consistent exercise of professional judgment in a manner that produces satisfactory outcomes. Alternative approaches may be used if the person proposing the alternative demonstrates that the approach meets all requirements of the statute and rules.
	Local Regulatory Requirement	None	None	None	None

Notes:
TBD To Be Determined.
NA Not Applicable.
* The U.S. Coast Guard solicited Applicable or Relevant and Appropriate Requirements (ARARs) from the State of Michigan in a letter dated September 25, 2008. A response from the MDEQ has not been received.
Potential State of Michigan ARARs and To Be Considered (TBCs) have been evaluated based on professional judgment consistent with other Sites in Michigan, where similar removal actions have been performed.

Table 2. Project Schedule for Removal Action, U.S. Coast Guard, Old Station Ludington, Ludington, Michigan

Activities	Organization	Anticipated Date(s) of Initiation	Anticipated Date of Completion
QAPP/FSP Preparation	U.S. Coast Guard/ARCADIS	July 2008	August 2008
USEPA Review of Documents	U.S. Coast Guard/ARCADIS/USEPA Region 5	July 2008	August 2008
EE/CA Report	U.S. Coast Guard/ARCADIS	August 2008	February 2009
Removal Action Work Plan	U.S. Coast Guard/ARCADIS	November 2008	February 2009
USEPA Review of Documents	U.S. Coast Guard/ARCADIS/USEPA Region 5	February 2009	April 2009
Public Participation Period	U.S. Coast Guard/ARCADIS	April 2009	May 2009
Site Preparation Activities	U.S. Coast Guard/ARCADIS	May 2009	June 2009
Removal Action Implementation	U.S. Coast Guard/ARCADIS	June 2009	July 2009
Removal Action Completion Report	U.S. Coast Guard/ARCADIS	July 2008	September 2009

FIGURES



UNITED STATES COAST GUARD
 STATION LUDINGTON
 LUDINGTON, MICHIGAN

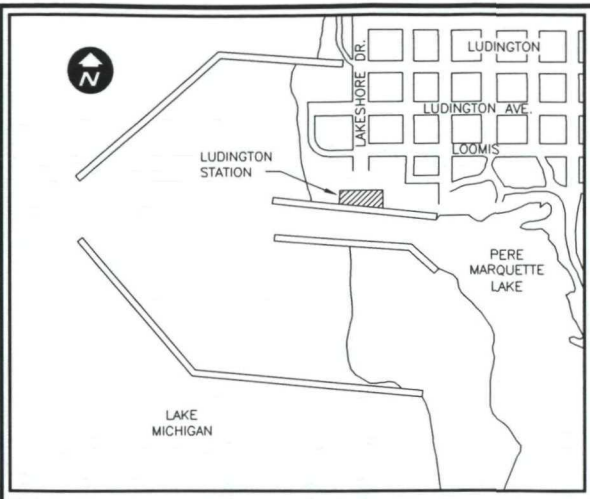
SITE LOCATION



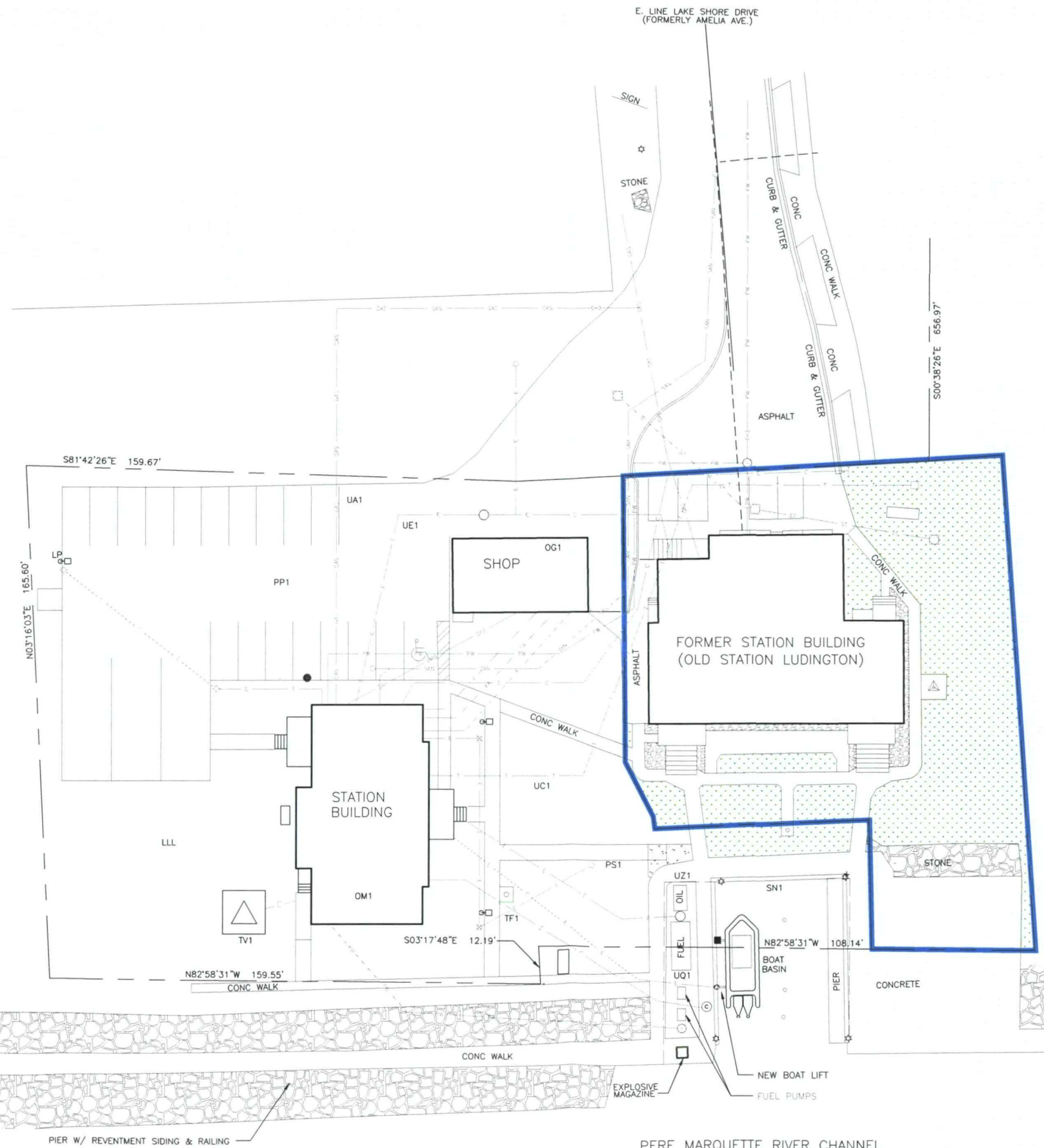
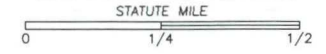
FIGURE

1

CITY: NOVI DIV: GROUP 1 DB: A. SMITH PIC: R. ELLIS PM: M. KITTINGER TM: T. SCLAFANI TR: G. ZELLMER PROJECT NUMBER: DE000122.0001.00 G:\GIS\Project Files\USCG\USCG Great Lakes\Ludington\CAD_Data\09-30397b.dwg LAYOUT: 02 SITE LAYOUT_V22.PLOT PLOTTED: 2/25/2009 2:04 PM BY: SMITH, ANTONIO



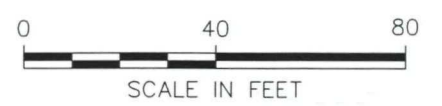
VICINITY MAP



REAL PROPERTY FACILITY NAME	
RPFN	FACILITY NAME
LLL	LAND
OG1	GARAGE
OM1	STATION BUILDING
PS1	SIDEWALKS
PP1	PARKING AREA
SN1	SSP BULKHEAD
TF1	FLAG POLE
TV1	RADIO TOWER FM 45'
UA1	GAS LINES
UC1	TELEPHONE SYSTEM
UE1	ELECTRICAL SYSTEM
UQ1	1500 GAL. F/O & 500 GAL. GAS CONVAULT
US1	SANITARY SEWER
US2	STORM SEWER
UW1	WATER
UZ1	250 GAL. W/O TANK (AG)

LEGEND

■	CATCH BASIN	—C—	COMM LINES
■	GREASE TRAP	—E—	ELECTRICAL
⊕	IRON PIPE	—GAS—	GAS
⊕	IRON ROD	—SAN—	SANITARY SEWER
⊕	LIGHT POLE	—ST—	STORM SEWER
●	MANHOLE-SANITARY SEWER	—T—	TELEPHONE
□	MANHOLE-STORM SEWER	—GAS/DSL—	GAS & DIESEL D.W. PIPE
⊕	ELECTRICAL OUTLET	—X—	FENCE
⊕	GAS METER	---	PROPERTY LINE
⊕	POWER POLE	—PW—	POTABLE WATER
■	PULL BOX	—AF—	FIRE ALARM
●	SHORE TIE/LIGHT		PORTION OF PROPERTY TO BE TRANSFERRED TO CITY OF LUDINGTON (SITE)
⊕	VALVE		GRASS
△	FORMER RADIO TOWER		LANDSCAPE ROCK

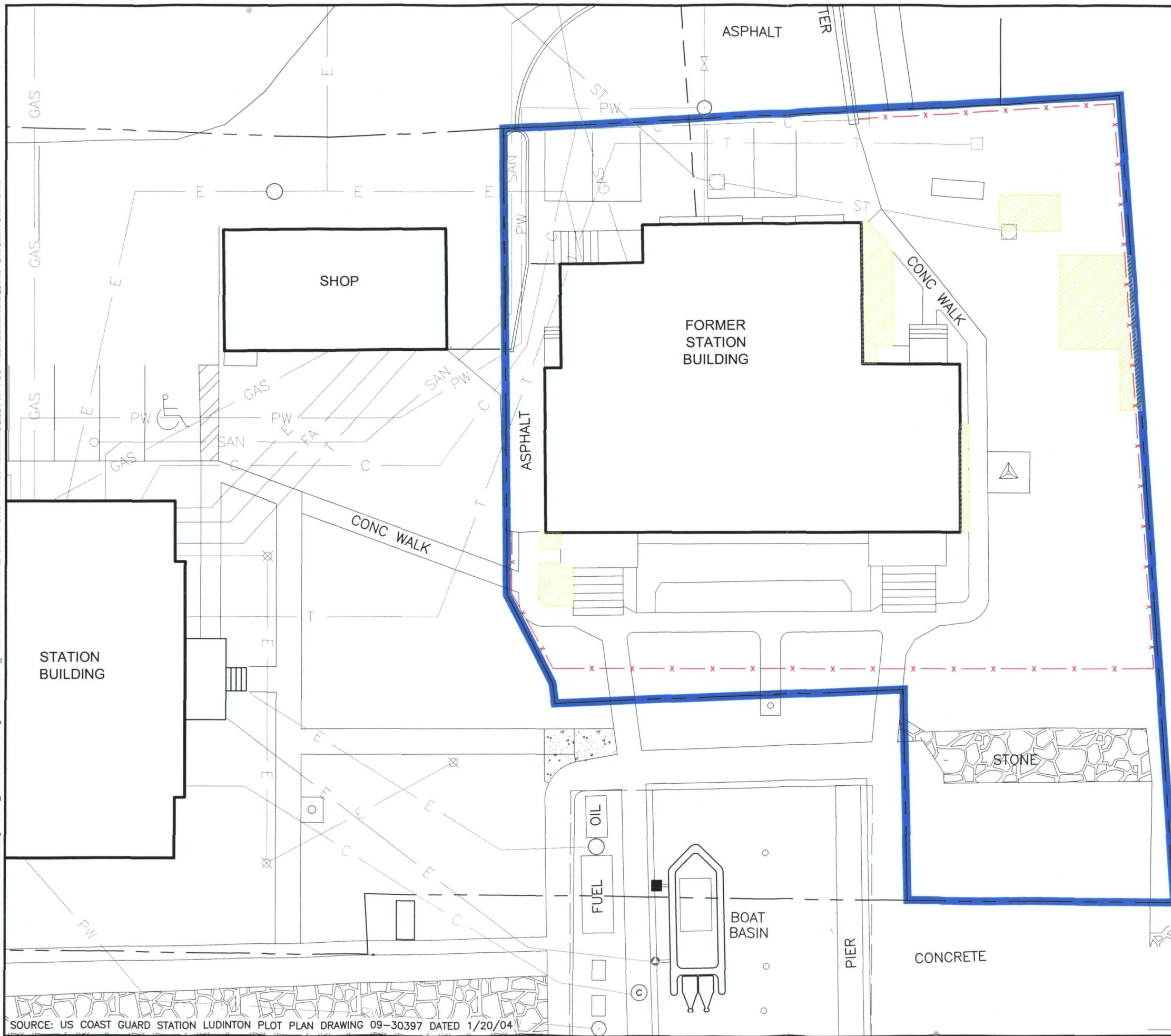


UNITED STATES COAST GUARD
STATION LUDINGTON
LUDINGTON, MICHIGAN

SITE LAYOUT WITH UTILITIES



CITY: NOVI DIV: GR... ENV DB: A. SMITH PIC: R. ELLIS PM: M. KITTINGER TM: T. SCLAFANI TR: G. ZELLMER PROJEC... NUMBER: DE000122.0001.000006
G:\GIS\Project Files\USCG\USCG Great Lakes\Ludington\CAD_Data\09-30397b.dwg LAYOUT: 04_PROPOSED EXTENT OF EXCAVATIONS PLOTTED: 2/25/2009 2:25 PM BY: SMITH, ANTONIO



LEGEND

- CATCH BASIN
- ⊞ GREASE TRAP
- ⊕ IRON PIPE
- ⊕ IRON ROD
- ⊕ LIGHT POLE
- MANHOLE-SANITARY SEWER
- MANHOLE-STORM SEWER
- ⊞ ELECTRICAL OUTLET
- ⊞ GAS METER
- ⊕ POWER POLE
- PULL BOX
- SHORE TIE/LIGHT
- ⊞ VALVE
- △ FORMER RADIO TOWER
- x - TEMPORARY CONSTRUCTION SAFETY FENCING TO BE INSTALLED PRIOR TO REMOVAL ACTION.
- - - PROPERTY LINE
- C - COMM LINES
- E - ELECTRICAL
- GAS - GAS
- SAN - SANITARY SEWER
- ST - STORM SEWER
- T - TELEPHONE
- GAS/DSL - GAS & DIESEL D.W. PIPE
- x - FENCE
- PW - POTABLE WATER
- AF - FIRE ALARM
- ▨ PROPOSED LATERAL EXTENT OF EXCAVATIONS
- ▭ PORTION OF PROPERTY TO BE TRANSFERRED TO CITY OF LUDINGTON (SITE)

NOTES:

EXTENT OF EXCAVATIONS IS APPROXIMATE. FINAL EXTENT OF EXCAVATIONS WILL BE DETERMINED BASED ON REMOVAL ACTION XRF FIELD SCREENING AND CONFIRMATION SAMPLE LABORATORY ANALYTICAL RESULTS.

TARGET DEPTH OF EXCAVATIONS IS 1-FOOT BELOW GROUND SURFACE.



SCALE IN FEET

UNITED STATES COAST GUARD
STATION LUDINGTON
LUDINGTON, MICHIGAN

PROPOSED EXTENT OF EXCAVATIONS



FIGURE
4

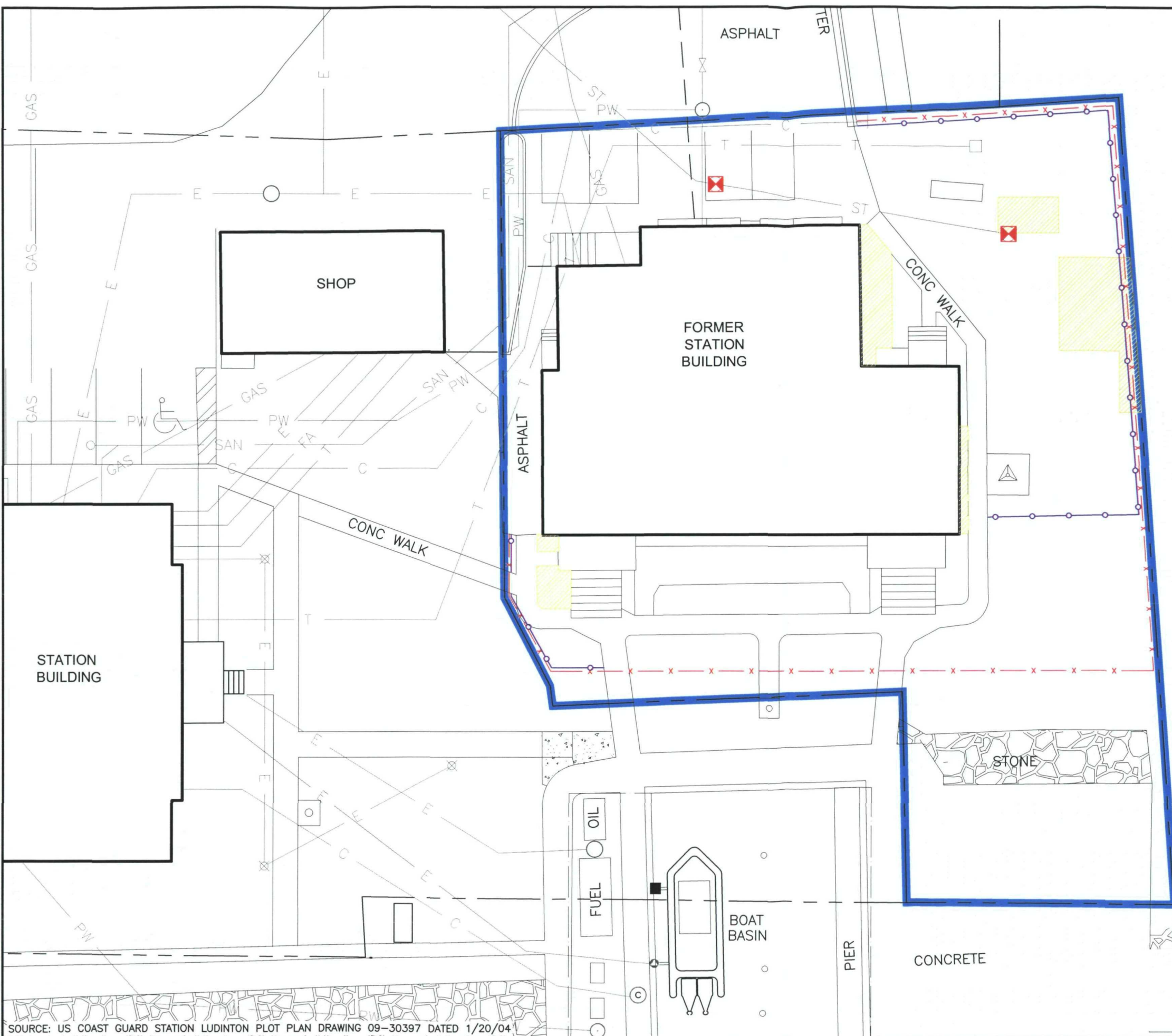
SOURCE: US COAST GUARD STATION LUDINGTON PLOT PLAN DRAWING 09-30397 DATED 1/20/04

ARCADIS

Appendix A

Soil Erosion and Sedimentation
Control Plan

CITY:NOVI DIV:GR... ENV DB:A. SMITH PIC:R. ELLIS PM:M. KITTINGER TM:T. SCLAFANI TR:G. ZELLMER PROJEC...MBER:DE000122.0001.00006
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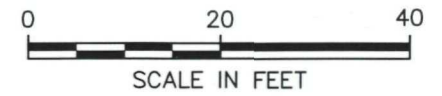
LEGEND

- CATCH BASIN
- ▣ GREASE TRAP
- ⊕ IRON PIPE
- ⊕ IRON ROD
- ⊕ LIGHT POLE
- MANHOLE-SANITARY SEWER
- MANHOLE-STORM SEWER
- ⊕ ELECTRICAL OUTLET
- ⊕ GAS METER
- ⊕ POWER POLE
- PULL BOX
- SHORE TIE/LIGHT
- ⊕ VALVE
- △ FORMER RADIO TOWER
- x - TEMPORARY CONSTRUCTION SAFETY FENCING TO BE INSTALLED PRIOR TO REMOVAL ACTION
- - - PROPOSED SILT FENCE
- - - PROPERTY LINE
- C - COMM LINES
- E - ELECTRICAL
- GAS - GAS
- SAN - SANITARY SEWER
- ST - STORM SEWER
- T - TELEPHONE
- GAS/DSL - GAS & DIESEL D.W. PIPE
- x - FENCE
- PW - POTABLE WATER
- AF - FIRE ALARM
- ⊕ PROPOSED INLET PROTECTION DEVICE (FILTER FABRIC)
- ▨ PROPOSED LATERAL EXTENT OF EXCAVATIONS
- ▭ PORTION OF PROPERTY TO BE TRANSFERRED TO CITY OF LUDINGTON (SITE)

NOTES:

EXTENT OF EXCAVATIONS IS APPROXIMATE. FINAL EXTENT OF EXCAVATIONS WILL BE DETERMINED BASED ON REMOVAL ACTION XRF FIELD SCREENING AND CONFIRMATION SAMPLE LABORATORY ANALYTICAL RESULTS.

TARGET DEPTH OF EXCAVATIONS IS 1-FOOT BELOW GROUND SURFACE.



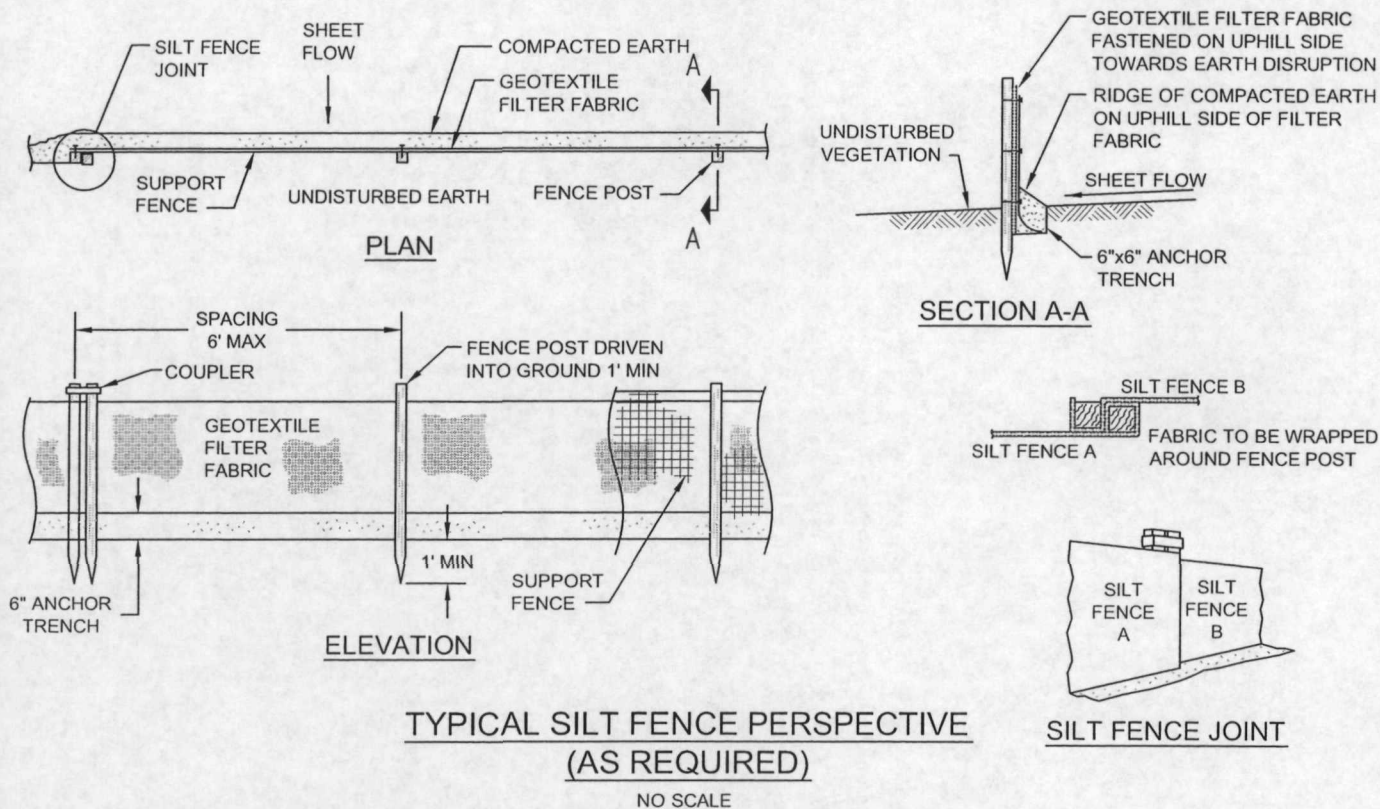
UNITED STATES COAST GUARD
STATION LUDINGTON
LUDINGTON, MICHIGAN

PROPOSED EXTENT OF EXCAVATIONS
WITH SOIL EROSION AND
SEDIMENTATION CONTROL MEASURES



FIGURE
A-1

DB: A. SMITH PIC: B. OMARA PM: J. LAGOWSKI TM: T. SCLAFANI TR: S. JERIC PROJECT NUMBER: M0009.
CG Great Lakes\Ludington\CAD_Data\09-30397b.dwg LAYOUT: A-2_SOILEROSIONCONTROLDETAILS PLOTTED: 3/5/2009 10:40 AM BY: SMITH, ANTONIO
CITY: NOVI DIV: GIS\GISProject Files



Soil Erosion and Sedimentation Control Plan; United States Coast Guard Station Ludington, Ludington, Michigan

Description of Project:

The project involves excavation and off-site disposal of impacted soil in the vicinity of the former station building. Soils with will be excavated and disposed in an off-site landfill.

The excavation will extend to a depth of approximately 1 foot below ground surface (ft bgs) in all areas. The approximate extent of soil excavations is presented on Figure A-1. It is estimated that a total of approximately 60 cubic yards of impacted soil will be removed from the Site.

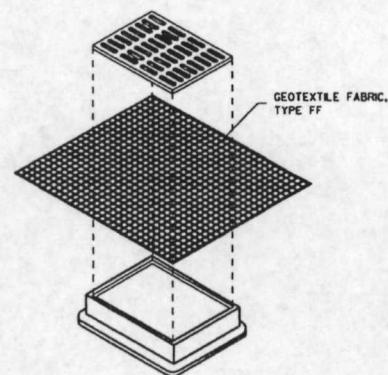
The anticipated project schedule is provided in the Removal Action Work Plan.

Construction Sequence and Methods:

1. Approximately 200 linear feet of silt fence will be installed around the perimeter of the excavation areas as shown on Figure A-1. An inlet protection device (filter fabric) shall be placed in the two catch basins located north of the former station building. Inspection of these features will be performed during active Site disturbance activities until the project is complete including Site restoration.
2. Approximately 60 cubic yards of impacted soil will be excavated and disposed at an off-site landfill. The excavation will extend to approximately 1 ft bgs. The excavated soil will be loaded directly into roll-off boxes positioned on the parking lot north of the former station building; therefore no stockpiling of soil is anticipated. Any soil tracked onto paved surfaces will be swept up daily.
3. Soil samples will be collected from the bottom and sidewalls of excavations following the removal of impacted soil in each location to verify the completeness of the removal. Soil samples will be sent to a laboratory for analysis. Once laboratory analysis indicates impacted soils have been removed, the excavation will be terminated and backfilled.
4. Approximately 60 cubic yards of clean soil backfill will be placed and compacted in the excavated areas. The excavation areas will be graded to match the pre-excavation site grade.
5. Site restoration will include adding 3 inches of topsoil, final grading and revegetation of the excavated areas with grass seed and straw mats.
6. The inlet protection device (filter fabric) for the two catch basins and the silt fencing will be removed after site restoration is complete and prior to demobilization.

Operations and Maintenance:

1. Inspections of the soil erosion and sedimentation controls will be performed during construction activities. Any damage to the silt fence or inlet protection devices will be documented and repaired or replaced as soon as possible once discovered.
2. Sediment deposits on the inlet protection devices shall be removed and the device restored to its original condition if sediment accumulates to a point that no longer allows the device to function as designed.
3. When removing or maintaining inlet protection devices, due care shall be taken to ensure sediment does not fall into the catch basin. Any material falling into the catch basin shall be immediately removed.



INSTALLATION NOTES

Trim excess fabric in the flow line to within 3" of the grate. contractor shall demonstrate a method of maintenance, using a sewn flap, hand holds or other method to prevent accumulated sediment from entering the inlet.

INLET PROTECTION DEVICE

NO SCALE

UNITED STATES COAST GUARD
STATION LUDINGTON
LUDINGTON, MICHIGAN

SOIL EROSION CONTROL DETAILS AND NOTES



FIGURE
A-2

ARCADIS

Appendix B

ARCADIS Standard Operating
Procedures

	Standard Operating Procedure	
	Soil Sampling Equipment Decontamination Procedure	

1. Applicability

- 1.1 This Standard Operating Procedure (SOP) covers the decontamination of soil sampling equipment, including split-spoons, hand augers, scoops, or other devices used to collect soil samples. Because of the potential for the decontamination equipment to be a source of contamination, the equipment must be inspected prior to each use for signs of contamination or wear and replaced frequently to prevent cross-contamination of samples.
- 1.2 This SOP does not address health and safety, sample collection, or laboratory analysis.

2. Equipment/Supplies

- 2.1 Detergent (Alconox, Liquinox, TSP, etc.)
- 2.2 Steam distilled water or laboratory grade de-ionized water
- 2.3 Squirt bottle
- 2.4 Scrub brush
- 2.5 5-gallon plastic buckets (2)
- 2.6 Plastic sheeting
- 2.7 Paper towels
- 2.8 Field Log Book

3. Procedure

- 3.1 Prepare a detergent solution in one of the buckets according to the detergent manufacturer's directions.
- 3.2 Partially fill the second bucket with distilled water.
- 3.3 Remove soil or other material on the sampling device with tools or paper towels.

- 3.4 After the materials are removed from the sampling device, immerse the device in the detergent solution and scrub with the brush.
- 3.5 Remove the device from the detergent solution and allow to drain for a moment prior to immersing the device in the rinse water bucket.
- 3.6 Immerse the device in the rinse water bucket and agitate the device.
- 3.7 Remove the device from the rinse water and give the device a final rinse with copious amounts of water from the squirt bottle. Allow the water to drain from the device.
- 3.8 The device may be returned to use. If the device will be stored prior to its next use, cover the device with plastic and store at a location away from potential sources of contamination.

	Standard Operating Procedure	
	Soil Sampling for Chemical Analysis of Lead	

1. Applicability

- 1.1 This Standard Operating Procedure (SOP) covers the collection of soil samples for lead analysis in accordance with the appropriate USEPA sampling method.
- 1.2 This SOP does not address health and safety, equipment decontamination, field parameter measurements, sample preservation, chain-of-custody, or laboratory analysis.

2. Equipment/Supplies

- 2.1 Stainless steel knife or spatula
- 2.2 Stainless steel spoon
- 2.3 Stainless steel bowl
- 2.4 Sample containers
- 2.5 Plastic sheeting
- 2.6 Coolers
- 2.7 Ice
- 2.8 Chain-of-Custody form
- 2.9 Field Log Book
- 2.10 Soil Sampling and Decontamination Equipment
- 2.11 Site-Specific Quality Assurance Project Plan (QAPP)
- 2.12 Field Sampling Plan (FSP) or Removal Action Work Plan (RAWP)

3. Procedure

- 3.1 Soil samples may be obtained using a split-spoon, auger, trowel, scoop, or other appropriate device for the situation. Soil samples for lead may be collected as “grab” or “composite” samples depending on the project needs. The equipment must be cleaned before each use following the Soil Sampling Equipment Decontamination SOP or equivalent.
- 3.2 Prior to placing the soil into the container, remove larger media such as gravel and organic debris.
- 3.3 If the samples will be composite samples, mix the sample portions in a pre-cleaned stainless steel bowl with a pre-cleaned stainless steel spoon.

- 3.4 Place the sample into the sample container and fill it as completely as possible. Properly label and manage the sample following procedures described in the QAPP and FSP/RAWP.
- 3.5 Duplicate samples are prepared by alternately filling the container for the "confirmation sample" for lead analysis and then filling the container for the "duplicate sample" for that same parameter. Duplicate samples need to be included on the Chain-of-Custody form. Refer to the QAPP for duplicate sample requirements.
- 3.6 Matrix spike/matrix spike duplicates (MS/MSDs) are collected in the same manner as a duplicate sample. Check with the laboratory for the volume requirements for each parameter. MS/MSDs need to be included on the Chain-of-Custody form. Refer to the QAPP for MS/MSD requirements.
- 3.7 Equipment blanks are prepared by running distilled water over each piece of the sampling equipment after it has been decontaminated. Equipment blanks are to be collected for each piece of sampling equipment individually; check the QAPP for further details concerning equipment blank collection. Equipment blanks need to be included on the Chain-of-Custody form.
- 3.10 Samples should be placed into a cooler containing ice immediately after collection.
- 3.11 Ship the samples to the laboratory per project requirements following the Chain-of-Custody procedure described in the QAPP.

	Standard Operating Procedure	
	Surveying	

1. **Applicability**

A level survey of borings, monitoring wells, or various Site characteristics at each site is performed in order to: establish the elevation of the groundwater table; determine the direction of groundwater flow; define the subsurface stratigraphy; and to accurately locate the physical features at each site so that a base map can be created.

2. **Equipment/Supplies**

- Field book
- Pencils
- Transit or level
- Survey rod
- Tripod
- 200' tape to measure distances
- Spray paint, permanent marker
- Copies of available maps such as topographic, site, site vicinity
- Copies of previous sketches showing borings/wells location and number
- Safety cones or barricades

3. **Procedure**

3.1 **Equipment Handling**

- The level/transit is a sensitive, expensive instrument. Handle it accordingly. Keep it dry and clean as possible. Never carry the instrument in the back of the truck.
- Never leave the instrument on the tripod without securely attaching it.
- Make sure that the tripod is stable at all times.
- Always setup the tripod and instrument so that it is easily seen.
- Never leave a tripod and instrument unattended when surveying in an area with vehicular traffic. Place protective cones around the survey station.

- Keep an eye on the equipment at all times.
- Keep the survey rod free of dirt and grit.

3.2 Leveling the Instrument

- Center the level and screw it onto the tripod.
- Firmly plant the tripod legs.
- Use foot screw to level the instrument. The bubble must be within the setting circle in order for the instrument to be level.
- Rotate the level 360 degrees, checking to be sure that the bubble remains inside the circle at every point.

3.3 Focusing the Cross Hairs and Siting

- To focus the cross hairs, look through the instrument and turn the ring around the eyepiece until the hairs come into focus.
- Relax your eye while looking through the eyepiece.
- Use a sun shade.

3.4 Rod

- Be careful when using a rod around overhead power and utility lines.
- The rod is graduated into hundredths of a foot. The bottom of each black line is an odd hundredth; the top of each black line is an even hundredth.
- When surveying to the rod, the rod should be moved forward and back to determine the lowest, and most accurate, reading.

3.5 Stadia Surveys

- Readings should be taken at the intersection of the vertical cross hair with the three horizontal cross hairs (a level survey requires reading only the center cross hair).
- Distance (D) calculation:

$$D = (\text{High Stadia} - \text{Low Stadia}) \times 100$$

ex:

$$\text{High Stadia} = 8.87 \quad D = (8.87 - 8.29) \times 100$$

$$\text{Low Stadia} = 8.2 \quad D = 58.0$$

- Check the accuracy of your readings as you survey. An acceptable error is 1/100' difference between calculations per siting.

- Check Readings: high - mid = mid - low

3.6 Bench Marks

- Clearly note the location and type of the bench mark used for each survey. The location should be marked permanently in the field so that it may be reused.

- If an existing bench mark with a known elevation is within a reasonable distance of the site, the surveyors should attempt to use it as the bench mark for the survey. Possible existing bench marks are sewer manhole rims, storm drains, USGS (from topo map).

- If there is no known bench mark in the area, a bench mark must be created arbitrarily.

- Use the following guidelines for establishing an arbitrary bench mark:

a) use permanent physical features such as the corner of a pump island, cement floor slab, manhole or sewer rim.

b) assign an elevation to the bench mark; if the nearest 10-foot contour is known, use it as the BM elevation; if the contour elevation is not known assign an arbitrary elevation.

c) clearly note the location and elevation of the BM in the field and on all site plans.

d) Do not use monitoring or recovery wells as bench marks.

3.7 Level Surveys

- When surveying wells, make certain to choose a survey point that can be used when gauging the well; if the top of the PVC casing is greater than 6 inches below the ground surface do not use it as the survey point, instead use the lip or rim of the protective casing. Clearly note the survey point of each well in the survey notes.

- Permanently mark the survey point with paint or permanent marker.
- Place the rod on the survey point and hold it vertical; move it backwards and forwards to determine the most accurate reading.
- Calculate the elevation from the middle cross hair reading.
- Limit the number of times the instrument must be moved.
- After completing level readings at each set up, shoot back to two or more wells to close the level run.
- In a multiple-station survey, always shoot at least two known points for each station.
- Calculate elevations before moving instrument to determine if there are any irregularities or errors.

3.8 Turning Points

- A Turning Point (TP) is used when all of the survey points cannot be seen from one instrument position and the instrument must be moved.
- The TP essentially establishes a new bench mark from which a new height of instrument is calculated.
- A TP can be a permanent structure, a PK, the original BM, or a well. (A PK is a surveyor's nail driven into the ground/asphalt to create a hub for the rod to rest upon).
- Complete the following steps to create a TP:
 - a) take a FS (foresight) on the TP and record the measurement under the FS column in the field book;
 - b) the FS is subtracted from the HI (height of instrument) for the current instrument location to determine the elevation of the TP;
 - c) the instrument is then moved to a new location and leveled;
 - d) a BS (backsight) reading is taken to the TP and entered in the BS column in the field book;
 - e) the BS is added to the TP to determine the new HI elevation;
 - f) note: the TP entry in the survey data in the field book will always have 4 entries: BS, FS, HI, and elevation.

3.9 Taping Locations

- Use a tape to verify distances that were surveyed with the instrument.
- Obtain three measurements for each location.
- Pull the tape tightly between points being measured.
- Measure dimensions of buildings on site to confirm base maps.

3.10 General

- When surveying wells, choose a survey point that can be used when gauging the well.
- If the top of the well casing is greater than 6 inches below the ground surface, DO NOT use the well casing as the survey point; instead, use the lip or rim of the protective casing as the survey point.
- Obtain the following for each monitoring well survey location:
 - a) the elevation of the top of the well casing (T.O.C.);
 - b) the elevation of the lip or rim of the protective casing (T.O.R.);
 - c) the elevation of the ground surface adjacent to the well (T.O.G.).
- Where there is a significant topographic change across a site, additional survey information will be required in order to document the ground surface elevation differences; this information is critical when drawing cross-sections and in planning trenching and infiltration gallery installations.

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE
DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT

SW-846 is not intended to be an analytical training manual. Therefore, method procedures are written based on the assumption that they will be performed by analysts who are formally trained in at least the basic principles of chemical analysis and in the use of the subject technology.

In addition, SW-846 methods, with the exception of required method use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique which a laboratory can use as a basic starting point for generating its own detailed Standard Operating Procedure (SOP), either for its own general use or for a specific project application. The performance data included in this method are for guidance purposes only, and are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to the in situ and intrusive analysis of the 26 analytes listed below for soil and sediment samples. Some common elements are not listed in this method because they are considered "light" elements that cannot be detected by field portable x-ray fluorescence (FPXRF). These light elements are: lithium, beryllium, sodium, magnesium, aluminum, silicon, and phosphorus. Most of the analytes listed below are of environmental concern, while a few others have interference effects or change the elemental composition of the matrix, affecting quantitation of the analytes of interest. Generally elements of atomic number 16 or greater can be detected and quantitated by FPXRF. The following RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Antimony (Sb)	7440-36-0
Arsenic (As)	7440-38-0
Barium (Ba)	7440-39-3
Cadmium (Cd)	7440-43-9
Chromium (Cr)	7440-47-3
Cobalt (Co)	7440-48-4
Copper (Cu)	7440-50-8
Lead (Pb)	7439-92-1
Mercury (Hg)	7439-97-6
Nickel (Ni)	7440-02-0
Selenium (Se)	7782-49-2
Silver (Ag)	7440-22-4
Thallium (Tl)	7440-28-0
Tin (Sn)	7440-31-5

Analytes	CAS Registry No.
Vanadium (V)	7440-62-2
Zinc (Zn)	7440-66-6

In addition, the following non-RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Calcium (Ca)	7440-70-2
Iron (Fe)	7439-89-6
Manganese (Mn)	7439-96-5
Molybdenum (Mo)	7439-93-7
Potassium (K)	7440-09-7
Rubidium (Rb)	7440-17-7
Strontium (Sr)	7440-24-6
Thorium (Th)	7440-29-1
Titanium (Ti)	7440-32-6
Zirconium (Zr)	7440-67-7

1.2 This method is a screening method to be used with confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnace atomic absorption spectrometry (GFAA), inductively coupled plasma-atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)). This method's main strength is that it is a rapid field screening procedure. The method's lower limits of detection are typically above the toxicity characteristic regulatory level for most RCRA analytes. However, when the obtainable values for precision, accuracy, and laboratory-established sensitivity of this method meet project-specific data quality objectives (DQOs), FPXRF is a fast, powerful, cost effective technology for site characterization.

1.3 The method sensitivity or lower limit of detection depends on several factors, including the analyte of interest, the type of detector used, the type of excitation source, the strength of the excitation source, count times used to irradiate the sample, physical matrix effects, chemical matrix effects, and interelement spectral interferences. Example lower limits of detection for analytes of interest in environmental applications are shown in Table 1. These limits apply to a clean spiked matrix of quartz sand (silicon dioxide) free of interelement spectral interferences using long (100 -600 second) count times. These sensitivity values are given for guidance only and may not always be achievable, since they will vary depending on the sample matrix, which instrument is used, and operating conditions. A discussion of performance-based sensitivity is presented in Sec. 9.6.

1.4 Analysts should consult the disclaimer statement at the front of the manual and the information in Chapter Two for guidance on the intended flexibility in the choice of methods, apparatus, materials, reagents, and supplies, and on the responsibilities of the analyst for demonstrating that the techniques employed are appropriate for the analytes of interest, in the matrix of interest, and at the levels of concern.

In addition, analysts and data users are advised that, except where explicitly specified in a regulation, the use of SW-846 methods is *not* mandatory in response to Federal testing requirements. The information contained in this method is provided by EPA as guidance to be used by the analyst and the regulated community in making judgments necessary to generate results that meet the data quality objectives for the intended application.

1.5 Use of this method is restricted to use by, or under supervision of, personnel appropriately experienced and trained in the use and operation of an XRF instrument. Each analyst must demonstrate the ability to generate acceptable results with this method.

2.0 SUMMARY OF METHOD

2.1 The FPXRF technologies described in this method use either sealed radioisotope sources or x-ray tubes to irradiate samples with x-rays. When a sample is irradiated with x-rays, the source x-rays may undergo either scattering or absorption by sample atoms. This latter process is known as the photoelectric effect. When an atom absorbs the source x-rays, the incident radiation dislodges electrons from the innermost shells of the atom, creating vacancies. The electron vacancies are filled by electrons cascading in from outer electron shells. Electrons in outer shells have higher energy states than inner shell electrons, and the outer shell electrons give off energy as they cascade down into the inner shell vacancies. This rearrangement of electrons results in emission of x-rays characteristic of the given atom. The emission of x-rays, in this manner, is termed x-ray fluorescence.

Three electron shells are generally involved in emission of x-rays during FPXRF analysis of environmental samples. The three electron shells include the K, L, and M shells. A typical emission pattern, also called an emission spectrum, for a given metal has multiple intensity peaks generated from the emission of K, L, or M shell electrons. The most commonly measured x-ray emissions are from the K and L shells; only metals with an atomic number greater than 57 have measurable M shell emissions.

Each characteristic x-ray line is defined with the letter K, L, or M, which signifies which shell had the original vacancy and by a subscript alpha (α), beta (β), or gamma (γ) etc., which indicates the higher shell from which electrons fell to fill the vacancy and produce the x-ray. For example, a K_α line is produced by a vacancy in the K shell filled by an L shell electron, whereas a K_β line is produced by a vacancy in the K shell filled by an M shell electron. The K_α transition is on average 6 to 7 times more probable than the K_β transition; therefore, the K_α line is approximately 7 times more intense than the K_β line for a given element, making the K_α line the choice for quantitation purposes.

The K lines for a given element are the most energetic lines and are the preferred lines for analysis. For a given atom, the x-rays emitted from L transitions are always less energetic than those emitted from K transitions. Unlike the K lines, the main L emission lines (L_α and L_β) for an element are of nearly equal intensity. The choice of one or the other depends on what interfering element lines might be present. The L emission lines are useful for analyses involving elements of atomic number (Z) 58 (cerium) through 92 (uranium).

An x-ray source can excite characteristic x-rays from an element only if the source energy is greater than the absorption edge energy for the particular line group of the element, that is, the K absorption edge, L absorption edge, or M absorption edge energy. The absorption edge energy is somewhat greater than the corresponding line energy. Actually, the K absorption edge energy is approximately the sum of the K, L, and M line energies of the particular element, and the L absorption edge energy is approximately the sum of the L and M line energies. FPXRF is more sensitive to an element with an absorption edge energy close to but less than

the excitation energy of the source. For example, when using a cadmium-109 source, which has an excitation energy of 22.1 kiloelectron volts (keV), FPXRF would exhibit better sensitivity for zirconium which has a K line energy of 15.77 keV than to chromium, which has a K line energy of 5.41 keV.

2.2 Under this method, inorganic analytes of interest are identified and quantitated using a field portable energy-dispersive x-ray fluorescence spectrometer. Radiation from one or more radioisotope sources or an electrically excited x-ray tube is used to generate characteristic x-ray emissions from elements in a sample. Up to three sources may be used to irradiate a sample. Each source emits a specific set of primary x-rays that excite a corresponding range of elements in a sample. When more than one source can excite the element of interest, the source is selected according to its excitation efficiency for the element of interest.

For measurement, the sample is positioned in front of the probe window. This can be done in two manners using FPXRF instruments, specifically, in situ or intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. The sample cup is then placed on top of the window inside a protective cover for analysis.

Sample analysis is then initiated by exposing the sample to primary radiation from the source. Fluorescent and backscattered x-rays from the sample enter through the detector window and are converted into electric pulses in the detector. The detector in FPXRF instruments is usually either a solid-state detector or a gas-filled proportional counter. Within the detector, energies of the characteristic x-rays are converted into a train of electric pulses, the amplitudes of which are linearly proportional to the energy of the x-rays. An electronic multichannel analyzer (MCA) measures the pulse amplitudes, which is the basis of qualitative x-ray analysis. The number of counts at a given energy per unit of time is representative of the element concentration in a sample and is the basis for quantitative analysis. Most FPXRF instruments are menu-driven from software built into the units or from personal computers (PC).

The measurement time of each source is user-selectable. Shorter source measurement times (30 seconds) are generally used for initial screening and hot spot delineation, and longer measurement times (up to 300 seconds) are typically used to meet higher precision and accuracy requirements.

FPXRF instruments can be calibrated using the following methods: internally using fundamental parameters determined by the manufacturer, empirically based on site-specific calibration standards (SSCS), or based on Compton peak ratios. The Compton peak is produced by backscattering of the source radiation. Some FPXRF instruments can be calibrated using multiple methods.

3.0 DEFINITIONS

- 3.1 FPXRF -- Field portable x-ray fluorescence.
- 3.2 MCA -- Multichannel analyzer for measuring pulse amplitude.
- 3.3 SSCS -- Site-specific calibration standards.
- 3.4 FP -- Fundamental parameter.
- 3.5 ROI -- Region of interest.

3.6 SRM -- Standard reference material; a standard containing certified amounts of metals in soil or sediment.

3.7 eV -- Electron volt; a unit of energy equivalent to the amount of energy gained by an electron passing through a potential difference of one volt.

3.8 Refer to Chapter One, Chapter Three, and the manufacturer's instructions for other definitions that may be relevant to this procedure.

4.0 INTERFERENCES

4.1 The total method error for FPXRF analysis is defined as the square root of the sum of squares of both instrument precision and user- or application-related error. Generally, instrument precision is the least significant source of error in FPXRF analysis. User- or application-related error is generally more significant and varies with each site and method used. Some sources of interference can be minimized or controlled by the instrument operator, but others cannot. Common sources of user- or application-related error are discussed below.

4.2 Physical matrix effects result from variations in the physical character of the sample. These variations may include such parameters as particle size, uniformity, homogeneity, and surface condition. For example, if any analyte exists in the form of very fine particles in a coarser-grained matrix, the analyte's concentration measured by the FPXRF will vary depending on how fine particles are distributed within the coarser-grained matrix. If the fine particles "settle" to the bottom of the sample cup (i.e., against the cup window), the analyte concentration measurement will be higher than if the fine particles are not mixed in well and stay on top of the coarser-grained particles in the sample cup. One way to reduce such error is to grind and sieve all soil samples to a uniform particle size thus reducing sample-to-sample particle size variability. Homogeneity is always a concern when dealing with soil samples. Every effort should be made to thoroughly mix and homogenize soil samples before analysis. Field studies have shown heterogeneity of the sample generally has the largest impact on comparability with confirmatory samples.

4.3 Moisture content may affect the accuracy of analysis of soil and sediment sample analyses. When the moisture content is between 5 and 20 percent, the overall error from moisture may be minimal. However, moisture content may be a major source of error when analyzing samples of surface soil or sediment that are saturated with water. This error can be minimized by drying the samples in a convection or toaster oven. Microwave drying is not recommended because field studies have shown that microwave drying can increase variability between FPXRF data and confirmatory analysis and because metal fragments in the sample can cause arcing to occur in a microwave.

4.4 Inconsistent positioning of samples in front of the probe window is a potential source of error because the x-ray signal decreases as the distance from the radioactive source increases. This error is minimized by maintaining the same distance between the window and each sample. For the best results, the window of the probe should be in direct contact with the sample, which means that the sample should be flat and smooth to provide a good contact surface.

4.5 Chemical matrix effects result from differences in the concentrations of interfering elements. These effects occur as either spectral interferences (peak overlaps) or as x-ray absorption and enhancement phenomena. Both effects are common in soils contaminated with heavy metals. As examples of absorption and enhancement effects; iron (Fe) tends to absorb copper (Cu) x-rays, reducing the intensity of the Cu measured by the detector, while chromium (Cr) will be enhanced at the expense of Fe because the absorption edge of Cr is slightly lower in energy than the fluorescent peak of iron. The effects can be corrected mathematically through the use of fundamental parameter (FP) coefficients. The effects also can be compensated for using SSCS, which contain all the elements present on site that can interfere with one another.

4.6 When present in a sample, certain x-ray lines from different elements can be very close in energy and, therefore, can cause interference by producing a severely overlapped spectrum. The degree to which a detector can resolve the two different peaks depends on the energy resolution of the detector. If the energy difference between the two peaks in electron volts is less than the resolution of the detector in electron volts, then the detector will not be able to fully resolve the peaks.

The most common spectrum overlaps involve the K_β line of element Z-1 with the K_α line of element Z. This is called the K_α/K_β interference. Because the $K_\alpha:K_\beta$ intensity ratio for a given element usually is about 7:1, the interfering element, Z-1, must be present at large concentrations to cause a problem. Two examples of this type of spectral interference involve the presence of large concentrations of vanadium (V) when attempting to measure Cr or the presence of large concentrations of Fe when attempting to measure cobalt (Co). The V K_α and K_β energies are 4.95 and 5.43 keV, respectively, and the Cr K_α energy is 5.41 keV. The Fe K_α and K_β energies are 6.40 and 7.06 keV, respectively, and the Co K_α energy is 6.92 keV. The difference between the V K_β and Cr K_α energies is 20 eV, and the difference between the Fe K_β and the Co K_α energies is 140 eV. The resolution of the highest-resolution detectors in FPXRF instruments is 170 eV. Therefore, large amounts of V and Fe will interfere with quantitation of Cr or Co, respectively. The presence of Fe is a frequent problem because it is often found in soils at tens of thousands of parts per million (ppm).

4.7 Other interferences can arise from K/L, K/M, and L/M line overlaps, although these overlaps are less common. Examples of such overlap involve arsenic (As) K_α /lead (Pb) L_α and sulfur (S) K_α /Pb M_α . In the As/Pb case, Pb can be measured from the Pb L_β line, and As can be measured from either the As K_α or the As K_β line; in this way the interference can be corrected. If the As K_β line is used, sensitivity will be decreased by a factor of two to five times because it is a less intense line than the As K_α line. If the As K_α line is used in the presence of Pb, mathematical corrections within the instrument software can be used to subtract out the Pb interference. However, because of the limits of mathematical corrections, As concentrations cannot be efficiently calculated for samples with Pb:As ratios of 10:1 or more. This high ratio of Pb to As may result in reporting of a "nondetect" or a "less than" value (e.g., <300 ppm) for As, regardless of the actual concentration present.

No instrument can fully compensate for this interference. It is important for an operator to understand this limitation of FPXRF instruments and consult with the manufacturer of the FPXRF instrument to evaluate options to minimize this limitation. The operator's decision will be based on action levels for metals in soil established for the site, matrix effects, capabilities of the instrument, data quality objectives, and the ratio of lead to arsenic known to be present at the site. If a site is encountered that contains lead at concentrations greater than ten times the concentration of arsenic it is advisable that all critical soil samples be sent off site for confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnace atomic absorption spectrometry (GFAA), inductively coupled plasma-

atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)).

4.8 If SSCS are used to calibrate an FPXRF instrument, the samples collected must be representative of the site under investigation. Representative soil sampling ensures that a sample or group of samples accurately reflects the concentrations of the contaminants of concern at a given time and location. Analytical results for representative samples reflect variations in the presence and concentration ranges of contaminants throughout a site. Variables affecting sample representativeness include differences in soil type, contaminant concentration variability, sample collection and preparation variability, and analytical variability, all of which should be minimized as much as possible.

4.9 Soil physical and chemical effects may be corrected using SSCS that have been analyzed by inductively coupled plasma (ICP) or atomic absorption (AA) methods. However, a major source of error can be introduced if these samples are not representative of the site or if the analytical error is large. Another concern is the type of digestion procedure used to prepare the soil samples for the reference analysis. Analytical results for the confirmatory method will vary depending on whether a partial digestion procedure, such as Method 3050, or a total digestion procedure, such as Method 3052, is used. It is known that depending on the nature of the soil or sediment, Method 3050 will achieve differing extraction efficiencies for different analytes of interest. The confirmatory method should meet the project-specific data quality objectives (DQOs).

XRF measures the total concentration of an element; therefore, to achieve the greatest comparability of this method with the reference method (reduced bias), a total digestion procedure should be used for sample preparation. However, in the study used to generate the performance data for this method (see Table 8), the confirmatory method used was Method 3050, and the FPXRF data compared very well with regression correlation coefficients (r often exceeding 0.95, except for barium and chromium). The critical factor is that the digestion procedure and analytical reference method used should meet the DQOs of the project and match the method used for confirmation analysis.

4.10 Ambient temperature changes can affect the gain of the amplifiers producing instrument drift. Gain or drift is primarily a function of the electronics (amplifier or preamplifier) and not the detector as most instrument detectors are cooled to a constant temperature. Most FPXRF instruments have a built-in automatic gain control. If the automatic gain control is allowed to make periodic adjustments, the instrument will compensate for the influence of temperature changes on its energy scale. If the FPXRF instrument has an automatic gain control function, the operator will not have to adjust the instrument's gain unless an error message appears. If an error message appears, the operator should follow the manufacturer's procedures for troubleshooting the problem. Often, this involves performing a new energy calibration. The performance of an energy calibration check to assess drift is a quality control measure discussed in Sec. 9.2.

If the operator is instructed by the manufacturer to manually conduct a gain check because of increasing or decreasing ambient temperature, it is standard to perform a gain check after every 10 to 20 sample measurements or once an hour whichever is more frequent. It is also suggested that a gain check be performed if the temperature fluctuates more than 10° F. The operator should follow the manufacturer's recommendations for gain check frequency.

5.0 SAFETY

5.1 This method does not address all safety issues associated with its use. The user is responsible for maintaining a safe work environment and a current awareness file of OSHA regulations regarding the safe handling of the chemicals listed in this method. A reference file of material safety data sheets (MSDSs) should be available to all personnel involved in these analyses.

NOTE: No MSDS applies directly to the radiation-producing instrument because that is covered under the Nuclear Regulatory Commission (NRC) or applicable state regulations.

5.2 Proper training for the safe operation of the instrument and radiation training should be completed by the analyst prior to analysis. Radiation safety for each specific instrument can be found in the operator's manual. Protective shielding should never be removed by the analyst or any personnel other than the manufacturer. The analyst should be aware of the local state and national regulations that pertain to the use of radiation-producing equipment and radioactive materials with which compliance is required. There should be a person appointed within the organization that is solely responsible for properly instructing all personnel, maintaining inspection records, and monitoring x-ray equipment at regular intervals.

Licenses for radioactive materials are of two types, specifically: (1) a general license which is usually initiated by the manufacturer for receiving, acquiring, owning, possessing, using, and transferring radioactive material incorporated in a device or equipment, and (2) a specific license which is issued to named persons for the operation of radioactive instruments as required by local, state, or federal agencies. A copy of the radioactive material license (for specific licenses only) and leak tests should be present with the instrument at all times and available to local and national authorities upon request.

X-ray tubes do not require radioactive material licenses or leak tests, but do require approvals and licenses which vary from state to state. In addition, fail-safe x-ray warning lights should be illuminated whenever an x-ray tube is energized. Provisions listed above concerning radiation safety regulations, shielding, training, and responsible personnel apply to x-ray tubes just as to radioactive sources. In addition, a log of the times and operating conditions should be kept whenever an x-ray tube is energized. An additional hazard present with x-ray tubes is the danger of electric shock from the high voltage supply, however, if the tube is properly positioned within the instrument, this is only a negligible risk. Any instrument (x-ray tube or radioisotope based) is capable of delivering an electric shock from the basic circuitry when the system is inappropriately opened.

5.3 Radiation monitoring equipment should be used with the handling and operation of the instrument. The operator and the surrounding environment should be monitored continually for analyst exposure to radiation. Thermal luminescent detectors (TLD) in the form of badges and rings are used to monitor operator radiation exposure. The TLDs or badges should be worn in the area of maximum exposure. The maximum permissible whole-body dose from occupational exposure is 5 Roentgen Equivalent Man (REM) per year. Possible exposure pathways for radiation to enter the body are ingestion, inhaling, and absorption. The best precaution to prevent radiation exposure is distance and shielding.

6.0 EQUIPMENT AND SUPPLIES

The mention of trade names or commercial products in this manual is for illustrative purposes only, and does not constitute an EPA endorsement or exclusive recommendation for

use. The products and instrument settings cited in SW-846 methods represent those products and settings used during method development or subsequently evaluated by the Agency. Glassware, reagents, supplies, equipment, and settings other than those listed in this manual may be employed provided that method performance appropriate for the intended application has been demonstrated and documented.

6.1 FPXRF spectrometer -- An FPXRF spectrometer consists of four major components: (1) a source that provides x-rays; (2) a sample presentation device; (3) a detector that converts x-ray-generated photons emitted from the sample into measurable electronic signals; and (4) a data processing unit that contains an emission or fluorescence energy analyzer, such as an MCA, that processes the signals into an x-ray energy spectrum from which elemental concentrations in the sample may be calculated, and a data display and storage system. These components and additional, optional items, are discussed below.

6.1.1 Excitation sources -- FPXRF instruments use either a sealed radioisotope source or an x-ray tube to provide the excitation source. Many FPXRF instruments use sealed radioisotope sources to produce x-rays in order to irradiate samples. The FPXRF instrument may contain between one and three radioisotope sources. Common radioisotope sources used for analysis for metals in soils are iron Fe-55 (^{55}Fe), cadmium Cd-109 (^{109}Cd), americium Am-241 (^{241}Am), and curium Cm-244 (^{244}Cm). These sources may be contained in a probe along with a window and the detector; the probe may be connected to a data reduction and handling system by means of a flexible cable. Alternatively, the sources, window, and detector may be included in the same unit as the data reduction and handling system.

The relative strength of the radioisotope sources is measured in units of millicuries (mCi). All other components of the FPXRF system being equal, the stronger the source, the greater the sensitivity and precision of a given instrument. Radioisotope sources undergo constant decay. In fact, it is this decay process that emits the primary x-rays used to excite samples for FPXRF analysis. The decay of radioisotopes is measured in "half-lives." The half-life of a radioisotope is defined as the length of time required to reduce the radioisotopes strength or activity by half. Developers of FPXRF technologies recommend source replacement at regular intervals based on the source's half-life. This is due to the ever increasing time required for the analysis rather than a decrease in instrument performance. The characteristic x-rays emitted from each of the different sources have energies capable of exciting a certain range of analytes in a sample. Table 2 summarizes the characteristics of four common radioisotope sources.

X-ray tubes have higher radiation output, no intrinsic lifetime limit, produce constant output over their lifetime, and do not have the disposal problems of radioactive sources but are just now appearing in FPXRF instruments. An electrically-excited x-ray tube operates by bombarding an anode with electrons accelerated by a high voltage. The electrons gain an energy in electron volts equal to the accelerating voltage and can excite atomic transitions in the anode, which then produces characteristic x-rays. These characteristic x-rays are emitted through a window which contains the vacuum necessary for the electron acceleration. An important difference between x-ray tubes and radioactive sources is that the electrons which bombard the anode also produce a continuum of x-rays across a broad range of energies in addition to the characteristic x-rays. This continuum is weak compared to the characteristic x-rays but can provide substantial excitation since it covers a broad energy range. It has the undesired property of producing background in the spectrum near the analyte x-ray lines when it is scattered by the sample. For this reason a filter is often used between the x-ray tube and the sample to suppress the continuum radiation while passing the characteristic x-rays from the anode. This filter is sometimes incorporated into the window of the x-ray tube. The choice of

accelerating voltage is governed both by the anode material, since the electrons must have sufficient energy to excite the anode, which requires a voltage greater than the absorption edge of the anode material and by the instrument's ability to cool the x-ray tube. The anode is most efficiently excited by voltages 2 to 2.5 times the edge energy (most x-rays per unit power to the tube), although voltages as low as 1.5 times the absorption edge energy will work. The characteristic x-rays emitted by the anode are capable of exciting a range of elements in the sample just as with a radioactive source. Table 3 gives the recommended operating voltages and the sample elements excited for some common anodes.

6.1.2 Sample presentation device -- FPXRF instruments can be operated in two modes: in situ and intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. For FPXRF instruments operated in the intrusive mode, the probe may be rotated so that the window faces either upward or downward. A protective sample cover is placed over the window, and the sample cup is placed on top of the window inside the protective sample cover for analysis.

6.1.3 Detectors -- The detectors in the FPXRF instruments can be either solid-state detectors or gas-filled, proportional counter detectors. Common solid-state detectors include mercuric iodide (HgI_2), silicon pin diode and lithium-drifted silicon $\text{Si}(\text{Li})$. The HgI_2 detector is operated at a moderately subambient temperature controlled by a low power thermoelectric cooler. The silicon pin diode detector also is cooled via the thermoelectric Peltier effect. The $\text{Si}(\text{Li})$ detector must be cooled to at least -90°C either with liquid nitrogen or by thermoelectric cooling via the Peltier effect. Instruments with a $\text{Si}(\text{Li})$ detector have an internal liquid nitrogen dewar with a capacity of 0.5 to 1.0 L. Proportional counter detectors are rugged and lightweight, which are important features of a field portable detector. However, the resolution of a proportional counter detector is not as good as that of a solid-state detector. The energy resolution of a detector for characteristic x-rays is usually expressed in terms of full width at half-maximum (FWHM) height of the manganese K_α peak at 5.89 keV. The typical resolutions of the above mentioned detectors are as follows: HgI_2 -270 eV; silicon pin diode-250 eV; $\text{Si}(\text{Li})$ -170 eV; and gas-filled, proportional counter-750 eV.

During operation of a solid-state detector, an x-ray photon strikes a biased, solid-state crystal and loses energy in the crystal by producing electron-hole pairs. The electric charge produced is collected and provides a current pulse that is directly proportional to the energy of the x-ray photon absorbed by the crystal of the detector. A gas-filled, proportional counter detector is an ionization chamber filled with a mixture of noble and other gases. An x-ray photon entering the chamber ionizes the gas atoms. The electric charge produced is collected and provides an electric signal that is directly proportional to the energy of the x-ray photon absorbed by the gas in the detector.

6.1.4 Data processing units -- The key component in the data processing unit of an FPXRF instrument is the MCA. The MCA receives pulses from the detector and sorts them by their amplitudes (energy level). The MCA counts pulses per second to determine the height of the peak in a spectrum, which is indicative of the target analyte's concentration. The spectrum of element peaks are built on the MCA. The MCAs in FPXRF instruments have from 256 to 2,048 channels. The concentrations of target analytes are usually shown in ppm on a liquid crystal display (LCD) in the instrument. FPXRF instruments can store both spectra and from 3,000 to 5,000 sets of numerical analytical results. Most FPXRF instruments are menu-driven from software built into the

units or from PCs. Once the data-storage memory of an FPXRF unit is full or at any other time, data can be downloaded by means of an RS-232 port and cable to a PC.

6.2 Spare battery and battery charger.

6.3 Polyethylene sample cups -- 31 to 40 mm in diameter with collar, or equivalent (appropriate for FPXRF instrument).

6.4 X-ray window film -- Mylar™, Kapton™, Spectrolene™, polypropylene, or equivalent; 2.5 to 6.0 µm thick.

6.5 Mortar and pestle -- Glass, agate, or aluminum oxide; for grinding soil and sediment samples.

6.6 Containers -- Glass or plastic to store samples.

6.7 Sieves -- 60-mesh (0.25 mm), stainless-steel, Nylon, or equivalent for preparing soil and sediment samples.

6.8 Trowels -- For smoothing soil surfaces and collecting soil samples.

6.9 Plastic bags -- Used for collection and homogenization of soil samples.

6.10 Drying oven -- Standard convection or toaster oven, for soil and sediment samples that require drying.

7.0 REAGENTS AND STANDARDS

7.1 Reagent grade chemicals must be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 Pure element standards -- Each pure, single-element standard is intended to produce strong characteristic x-ray peaks of the element of interest only. Other elements present must not contribute to the fluorescence spectrum. A set of pure element standards for commonly sought analytes is supplied by the instrument manufacturer, if designated for the instrument; not all instruments require the pure element standards. The standards are used to set the region of interest (ROI) for each element. They also can be used as energy calibration and resolution check samples.

7.3 Site-specific calibration standards -- Instruments that employ fundamental parameters (FP) or similar mathematical models in minimizing matrix effects may not require SSCS. If the FP calibration model is to be optimized or if empirical calibration is necessary, then SSCSs must be collected, prepared, and analyzed.

7.3.1 The SSCS must be representative of the matrix to be analyzed by FPXRF. These samples must be well homogenized. A minimum of 10 samples spanning the concentration ranges of the analytes of interest and of the interfering elements must be obtained from the site. A sample size of 4 to 8 ounces is recommended, and standard glass sampling jars should be used.

7.3.2 Each sample should be oven-dried for 2 to 4 hr at a temperature of less than 150 °C. If mercury is to be analyzed, a separate sample portion should be dried at ambient temperature as heating may volatilize the mercury. When the sample is dry, all large, organic debris and nonrepresentative material, such as twigs, leaves, roots, insects, asphalt, and rock should be removed. The sample should be homogenized (see Sec. 7.3.3) and then a representative portion ground with a mortar and pestle or other mechanical means, prior to passing through a 60-mesh sieve. Only the coarse rock fraction should remain on the screen.

7.3.3 The sample should be homogenized by using a riffle splitter or by placing 150 to 200 g of the dried, sieved sample on a piece of kraft or butcher paper about 1.5 by 1.5 feet in size. Each corner of the paper should be lifted alternately, rolling the soil over on itself and toward the opposite corner. The soil should be rolled on itself 20 times. Approximately 5 g of the sample should then be removed and placed in a sample cup for FPXRF analysis. The rest of the prepared sample should be sent off site for ICP or AA analysis. The method use for confirmatory analysis should meet the data quality objectives of the project.

7.4 Blank samples -- The blank samples should be from a "clean" quartz or silicon dioxide matrix that is free of any analytes at concentrations above the established lower limit of detection. These samples are used to monitor for cross-contamination and laboratory-induced contaminants or interferences.

7.5 Standard reference materials -- Standard reference materials (SRMs) are standards containing certified amounts of metals in soil or sediment. These standards are used for accuracy and performance checks of FPXRF analyses. SRMs can be obtained from the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), the Canadian National Research Council, and the national bureau of standards in foreign nations. Pertinent NIST SRMs for FPXRF analysis include 2704, Buffalo River Sediment; 2709, San Joaquin Soil; and 2710 and 2711, Montana Soil. These SRMs contain soil or sediment from actual sites that has been analyzed using independent inorganic analytical methods by many different laboratories. When these SRMs are unavailable, alternate standards may be used (e.g., NIST 2702).

8.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

Sample handling and preservation procedures used in FPXRF analyses should follow the guidelines in Chapter Three, "Inorganic Analytes."

9.0 QUALITY CONTROL

9.1 Follow the manufacturer's instructions for the quality control procedures specific to use of the testing product. Refer to Chapter One for additional guidance on quality assurance (QA) and quality control (QC) protocols. Any effort involving the collection of analytical data should include development of a structured and systematic planning document, such as a Quality Assurance Project Plan (QAPP) or a Sampling and Analysis Plan (SAP), which translates project objectives and specifications into directions for those that will implement the project and assess the results.

9.2 Energy calibration check -- To determine whether an FPXRF instrument is operating within resolution and stability tolerances, an energy calibration check should be run. The energy calibration check determines whether the characteristic x-ray lines are shifting,

which would indicate drift within the instrument. As discussed in Sec. 4.10, this check also serves as a gain check in the event that ambient temperatures are fluctuating greatly (more than 10 °F).

9.2.1 The energy calibration check should be run at a frequency consistent with manufacturer's recommendations. Generally, this would be at the beginning of each working day, after the batteries are changed or the instrument is shut off, at the end of each working day, and at any other time when the instrument operator believes that drift is occurring during analysis. A pure element such as iron, manganese, copper, or lead is often used for the energy calibration check. A manufacturer-recommended count time per source should be used for the check.

9.2.2 The instrument manufacturer's manual specifies the channel or kiloelectron volt level at which a pure element peak should appear and the expected intensity of the peak. The intensity and channel number of the pure element as measured using the source should be checked and compared to the manufacturer's recommendation. If the energy calibration check does not meet the manufacturer's criteria, then the pure element sample should be repositioned and reanalyzed. If the criteria are still not met, then an energy calibration should be performed as described in the manufacturer's manual. With some FPXRF instruments, once a spectrum is acquired from the energy calibration check, the peak can be optimized and realigned to the manufacturer's specifications using their software.

9.3 Blank samples -- Two types of blank samples should be analyzed for FPXRF analysis, specifically, instrument blanks and method blanks.

9.3.1 An instrument blank is used to verify that no contamination exists in the spectrometer or on the probe window. The instrument blank can be silicon dioxide, a polytetrafluoroethylene (PTFE) block, a quartz block, "clean" sand, or lithium carbonate. This instrument blank should be analyzed on each working day before and after analyses are conducted and once per every twenty samples. An instrument blank should also be analyzed whenever contamination is suspected by the analyst. The frequency of analysis will vary with the data quality objectives of the project. A manufacturer-recommended count time per source should be used for the blank analysis. No element concentrations above the established lower limit of detection should be found in the instrument blank. If concentrations exceed these limits, then the probe window and the check sample should be checked for contamination. If contamination is not a problem, then the instrument must be "zeroed" by following the manufacturer's instructions.

9.3.2 A method blank is used to monitor for laboratory-induced contaminants or interferences. The method blank can be "clean" silica sand or lithium carbonate that undergoes the same preparation procedure as the samples. A method blank must be analyzed at least daily. The frequency of analysis will depend on the data quality objectives of the project. If the method blank does not contain the target analyte at a level that interferes with the project-specific data quality objectives then the method blank would be considered acceptable. In the absence of project-specific data quality objectives, if the blank is less than the lowest level of detection or less than 10% of the lowest sample concentration for the analyte, whichever is greater, then the method blank would be considered acceptable. If the method blank cannot be considered acceptable, the cause of the problem must be identified, and all samples analyzed with the method blank must be reanalyzed.

9.4 Calibration verification checks -- A calibration verification check sample is used to check the accuracy of the instrument and to assess the stability and consistency of the analysis for the analytes of interest. A check sample should be analyzed at the beginning of each working day, during active sample analyses, and at the end of each working day. The frequency of calibration checks during active analysis will depend on the data quality objectives of the project. The check sample should be a well characterized soil sample from the site that is representative of site samples in terms of particle size and degree of homogeneity and that contains contaminants at concentrations near the action levels. If a site-specific sample is not available, then an NIST or other SRM that contains the analytes of interest can be used to verify the accuracy of the instrument. The measured value for each target analyte should be within ± 20 percent (%D) of the true value for the calibration verification check to be acceptable. If a measured value falls outside this range, then the check sample should be reanalyzed. If the value continues to fall outside the acceptance range, the instrument should be recalibrated, and the batch of samples analyzed before the unacceptable calibration verification check must be reanalyzed.

9.5 Precision measurements -- The precision of the method is monitored by analyzing a sample with low, moderate, or high concentrations of target analytes. The frequency of precision measurements will depend on the data quality objectives for the data. A minimum of one precision sample should be run per day. Each precision sample should be analyzed 7 times in replicate. It is recommended that precision measurements be obtained for samples with varying concentration ranges to assess the effect of concentration on method precision. Determining method precision for analytes at concentrations near the site action levels can be extremely important if the FPXRF results are to be used in an enforcement action; therefore, selection of at least one sample with target analyte concentrations at or near the site action levels or levels of concern is recommended. A precision sample is analyzed by the instrument for the same field analysis time as used for other project samples. The relative standard deviation (RSD) of the sample mean is used to assess method precision. For FPXRF data to be considered adequately precise, the RSD should not be greater than 20 percent with the exception of chromium. RSD values for chromium should not be greater than 30 percent. If both in situ and intrusive analytical techniques are used during the course of one day, it is recommended that separate precision calculations be performed for each analysis type.

The equation for calculating RSD is as follows:

$$\text{RSD} = (\text{SD}/\text{Mean Concentration}) \times 100$$

where:

RSD	=	Relative standard deviation for the precision measurement for the analyte
SD	=	Standard deviation of the concentration for the analyte
Mean concentration	=	Mean concentration for the analyte

The precision or reproducibility of a measurement will improve with increasing count time, however, increasing the count time by a factor of 4 will provide only 2 times better precision, so there is a point of diminishing return. Increasing the count time also improves the sensitivity, but decreases sample throughput.

9.6 The lower limits of detection should be established from actual measured performance based on spike recoveries in the matrix of concern or from acceptable method performance on a certified reference material of the appropriate matrix and within the appropriate calibration range for the application. This is considered the best estimate of the true method sensitivity as opposed to a statistical determination based on the standard deviation of

replicate analyses of a low-concentration sample. While the statistical approach demonstrates the potential data variability for a given sample matrix at one point in time, it does not represent what can be detected or most importantly the lowest concentration that can be calibrated. For this reason the sensitivity should be established as the lowest point of detection based on acceptable target analyte recovery in the desired sample matrix.

9.7 Confirmatory samples -- The comparability of the FPXRF analysis is determined by submitting FPXRF-analyzed samples for analysis at a laboratory. The method of confirmatory analysis must meet the project and XRF measurement data quality objectives. The confirmatory samples must be splits of the well homogenized sample material. In some cases the prepared sample cups can be submitted. A minimum of 1 sample for each 20 FPXRF-analyzed samples should be submitted for confirmatory analysis. This frequency will depend on project-specific data quality objectives. The confirmatory analyses can also be used to verify the quality of the FPXRF data. The confirmatory samples should be selected from the lower, middle, and upper range of concentrations measured by the FPXRF. They should also include samples with analyte concentrations at or near the site action levels. The results of the confirmatory analysis and FPXRF analyses should be evaluated with a least squares linear regression analysis. If the measured concentrations span more than one order of magnitude, the data should be log-transformed to standardize variance which is proportional to the magnitude of measurement. The correlation coefficient (r) for the results should be 0.7 or greater for the FPXRF data to be considered screening level data. If the r is 0.9 or greater and inferential statistics indicate the FPXRF data and the confirmatory data are statistically equivalent at a 99 percent confidence level, the data could potentially meet definitive level data criteria.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Instrument calibration -- Instrument calibration procedures vary among FPXRF instruments. Users of this method should follow the calibration procedures outlined in the operator's manual for each specific FPXRF instrument. Generally, however, three types of calibration procedures exist for FPXRF instruments, namely: FP calibration, empirical calibration, and the Compton peak ratio or normalization method. These three types of calibration are discussed below.

10.2 Fundamental parameters calibration -- FP calibration procedures are extremely variable. An FP calibration provides the analyst with a "standardless" calibration. The advantages of FP calibrations over empirical calibrations include the following:

- No previously collected site-specific samples are necessary, although site-specific samples with confirmed and validated analytical results for all elements present could be used.
- Cost is reduced because fewer confirmatory laboratory results or calibration standards are necessary.

However, the analyst should be aware of the limitations imposed on FP calibration by particle size and matrix effects. These limitations can be minimized by adhering to the preparation procedure described in Sec. 7.3. The two FP calibration processes discussed below are based on an effective energy FP routine and a back scatter with FP (BFP) routine. Each FPXRF FP calibration process is based on a different iterative algorithmic method. The calibration procedure for each routine is explained in detail in the manufacturer's user manual for each FPXRF instrument; in addition, training courses are offered for each instrument.

10.2.1 Effective energy FP calibration -- The effective energy FP calibration is performed by the manufacturer before an instrument is sent to the analyst. Although SSCS can be used, the calibration relies on pure element standards or SRMs such as those obtained from NIST for the FP calibration. The effective energy routine relies on the spectrometer response to pure elements and FP iterative algorithms to compensate for various matrix effects.

Alpha coefficients are calculated using a variation of the Sherman equation, which calculates theoretical intensities from the measurement of pure element samples. These coefficients indicate the quantitative effect of each matrix element on an analyte's measured x-ray intensity. Next, the Lachance Traill algorithm is solved as a set of simultaneous equations based on the theoretical intensities. The alpha coefficients are then downloaded into the specific instrument.

The working effective energy FP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of sampling. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. A manufacturer-recommended count time per source should be used for the calibration check. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A percent difference (%D) is then calculated for each target analyte. The %D should be within ± 20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line or the y-intercept value for the analyte. The SRM or SSCS is reanalyzed until the %D falls within ± 20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

The equation to calibrate %D is as follows:

$$\%D = ((C_s - C_k) / C_k) \times 100$$

where:

%D = Percent difference

C_k = Certified concentration of standard sample

C_s = Measured concentration of standard sample

10.2.2 BFP calibration -- BFP calibration relies on the ability of the liquid nitrogen-cooled, Si(Li) solid-state detector to separate the coherent (Compton) and incoherent (Rayleigh) backscatter peaks of primary radiation. These peak intensities are known to be a function of sample composition, and the ratio of the Compton to Rayleigh peak is a function of the mass absorption of the sample. The calibration procedure is explained in detail in the instrument manufacturer's manual. Following is a general description of the BFP calibration procedure.

The concentrations of all detected and quantified elements are entered into the computer software system. Certified element results for an NIST SRM or confirmed and validated results for an SSCS can be used. In addition, the concentrations of oxygen and silicon must be entered; these two concentrations are not found in standard metals analyses. The manufacturer provides silicon and oxygen concentrations for typical soil types. Pure element standards are then analyzed using a manufacturer-recommended

count time per source. The results are used to calculate correction factors in order to adjust for spectrum overlap of elements.

The working BFP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of the analysis. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. The standard sample is analyzed using a manufacturer-recommended count time per source to check the calibration curve. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A %D is then calculated for each target analyte. The %D should fall within ± 20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line the y-intercept value for the analyte. The standard sample is reanalyzed until the %D falls within ± 20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

10.3 Empirical calibration -- An empirical calibration can be performed with SSCS, site-typical standards, or standards prepared from metal oxides. A discussion of SSCS is included in Sec. 7.3; if no previously characterized samples exist for a specific site, site-typical standards can be used. Site-typical standards may be selected from commercially available characterized soils or from SSCS prepared for another site. The site-typical standards should closely approximate the site's soil matrix with respect to particle size distribution, mineralogy, and contaminant analytes. If neither SSCS nor site-typical standards are available, it is possible to make gravimetric standards by adding metal oxides to a "clean" sand or silicon dioxide matrix that simulates soil. Metal oxides can be purchased from various chemical vendors. If standards are made on site, a balance capable of weighing items to at least two decimal places is necessary. Concentrated ICP or AA standard solutions can also be used to make standards. These solutions are available in concentrations of 10,000 parts per million, thus only small volumes have to be added to the soil.

An empirical calibration using SSCS involves analysis of SSCS by the FPXRF instrument and by a conventional analytical method such as ICP or AA. A total acid digestion procedure should be used by the laboratory for sample preparation. Generally, a minimum of 10 and a maximum of 30 well characterized SSCS, site-typical standards, or prepared metal oxide standards are necessary to perform an adequate empirical calibration. The exact number of standards depends on the number of analytes of interest and interfering elements. Theoretically, an empirical calibration with SSCS should provide the most accurate data for a site because the calibration compensates for site-specific matrix effects.

The first step in an empirical calibration is to analyze the pure element standards for the elements of interest. This enables the instrument to set channel limits for each element for spectral deconvolution. Next the SSCS, site-typical standards, or prepared metal oxide standards are analyzed using a count time of 200 seconds per source or a count time recommended by the manufacturer. This will produce a spectrum and net intensity of each analyte in each standard. The analyte concentrations for each standard are then entered into the instrument software; these concentrations are those obtained from the laboratory, the certified results, or the gravimetrically determined concentrations of the prepared standards. This gives the instrument analyte values to regress against corresponding intensities during the modeling stage. The regression equation correlates the concentrations of an analyte with its net intensity.

The calibration equation is developed using a least squares fit regression analysis. After the regression terms to be used in the equation are defined, a mathematical equation can be developed to calculate the analyte concentration in an unknown sample. In some FPXRF instruments, the software of the instrument calculates the regression equation. The software uses calculated intercept and slope values to form a multiterm equation. In conjunction with the software in the instrument, the operator can adjust the multiterm equation to minimize interelement interferences and optimize the intensity calibration curve.

It is possible to define up to six linear or nonlinear terms in the regression equation. Terms can be added and deleted to optimize the equation. The goal is to produce an equation with the smallest regression error and the highest correlation coefficient. These values are automatically computed by the software as the regression terms are added, deleted, or modified. It is also possible to delete data points from the regression line if these points are significant outliers or if they are heavily weighing the data. Once the regression equation has been selected for an analyte, the equation can be entered into the software for quantitation of analytes in subsequent samples. For an empirical calibration to be acceptable, the regression equation for a specific analyte should have a correlation coefficient of 0.98 or greater or meet the DQOs of the project.

In an empirical calibration, one must apply the DQOs of the project and ascertain critical or action levels for the analytes of interest. It is within these concentration ranges or around these action levels that the FPXRF instrument should be calibrated most accurately. It may not be possible to develop a good regression equation over several orders of analyte concentration.

10.4 Compton normalization method -- The Compton normalization method is based on analysis of a single, certified standard and normalization for the Compton peak. The Compton peak is produced from incoherent backscattering of x-ray radiation from the excitation source and is present in the spectrum of every sample. The Compton peak intensity changes with differing matrices. Generally, matrices dominated by lighter elements produce a larger Compton peak, and those dominated by heavier elements produce a smaller Compton peak. Normalizing to the Compton peak can reduce problems with varying matrix effects among samples. Compton normalization is similar to the use of internal standards in organics analysis. The Compton normalization method may not be effective when analyte concentrations exceed a few percent.

The certified standard used for this type of calibration could be an NIST SRM such as 2710 or 2711. The SRM must be a matrix similar to the samples and must contain the analytes of interests at concentrations near those expected in the samples. First, a response factor has to be determined for each analyte. This factor is calculated by dividing the net peak intensity by the analyte concentration. The net peak intensity is gross intensity corrected for baseline reading. Concentrations of analytes in samples are then determined by multiplying the baseline corrected analyte signal intensity by the normalization factor and by the response factor. The normalization factor is the quotient of the baseline corrected Compton K_{α} peak intensity of the SRM divided by that of the samples. Depending on the FPXRF instrument used, these calculations may be done manually or by the instrument software.

11.0 PROCEDURE

11.1 Operation of the various FPXRF instruments will vary according to the manufacturers' protocols. Before operating any FPXRF instrument, one should consult the manufacturer's manual. Most manufacturers recommend that their instruments be allowed to warm up for 15 to 30 minutes before analysis of samples. This will help alleviate drift or energy calibration problems later during analysis.

11.2 Each FPXRF instrument should be operated according to the manufacturer's recommendations. There are two modes in which FPXRF instruments can be operated: in situ and intrusive. The in situ mode involves analysis of an undisturbed soil sediment or sample. Intrusive analysis involves collection and preparation of a soil or sediment sample before analysis. Some FPXRF instruments can operate in both modes of analysis, while others are designed to operate in only one mode. The two modes of analysis are discussed below.

11.3 For in situ analysis, remove any large or nonrepresentative debris from the soil surface before analysis. This debris includes rocks, pebbles, leaves, vegetation, roots, and concrete. Also, the soil surface must be as smooth as possible so that the probe window will have good contact with the surface. This may require some leveling of the surface with a stainless-steel trowel. During the study conducted to provide example performance data for this method, this modest amount of sample preparation was found to take less than 5 min per sample location. The last requirement is that the soil or sediment not be saturated with water. Manufacturers state that their FPXRF instruments will perform adequately for soils with moisture contents of 5 to 20 percent but will not perform well for saturated soils, especially if ponded water exists on the surface. Another recommended technique for in situ analysis is to tamp the soil to increase soil density and compactness for better repeatability and representativeness. This condition is especially important for heavy element analysis, such as barium. Source count times for in situ analysis usually range from 30 to 120 seconds, but source count times will vary among instruments and depending on the desired method sensitivity. Due to the heterogeneous nature of the soil sample, in situ analysis can provide only "screening" type data.

11.4 For intrusive analysis of surface or sediment, it is recommended that a sample be collected from a 4- by 4-inch square that is 1 inch deep. This will produce a soil sample of approximately 375 g or 250 cm³, which is enough soil to fill an 8-ounce jar. However, the exact dimensions and sample depth should take into consideration the heterogeneous deposition of contaminants and will ultimately depend on the desired project-specific data quality objectives. The sample should be homogenized, dried, and ground before analysis. The sample can be homogenized before or after drying. The homogenization technique to be used after drying is discussed in Sec. 4.2. If the sample is homogenized before drying, it should be thoroughly mixed in a beaker or similar container, or if the sample is moist and has a high clay content, it can be kneaded in a plastic bag. One way to monitor homogenization when the sample is kneaded in a plastic bag is to add sodium fluorescein dye to the sample. After the moist sample has been homogenized, it is examined under an ultraviolet light to assess the distribution of sodium fluorescein throughout the sample. If the fluorescent dye is evenly distributed in the sample, homogenization is considered complete; if the dye is not evenly distributed, mixing should continue until the sample has been thoroughly homogenized. During the study conducted to provide data for this method, the time necessary for homogenization procedure using the fluorescein dye ranged from 3 to 5 min per sample. As demonstrated in Secs. 13.5 and 13.7, homogenization has the greatest impact on the reduction of sampling variability. It produces little or no contamination. Often, the direct analysis through the plastic bag is possible without the more labor intensive steps of drying, grinding, and sieving given in Secs. 11.5 and 11.6. Of course, to achieve the best data quality possible all four steps should be followed.

11.5 Once the soil or sediment sample has been homogenized, it should be dried. This can be accomplished with a toaster oven or convection oven. A small aliquot of the sample (20 to 50 g) is placed in a suitable container for drying. The sample should be dried for 2 to 4 hr in the convection or toaster oven at a temperature not greater than 150 °C. Samples may also be air dried under ambient temperature conditions using a 10- to 20-g portion. Regardless of what drying mechanism is used, the drying process is considered complete when a constant sample weight can be obtained. Care should be taken to avoid sample cross-contamination and these measures can be evaluated by including an appropriate method blank sample along with any sample preparation process.

CAUTION: Microwave drying is not a recommended procedure. Field studies have shown that microwave drying can increase variability between the FPXRF data and confirmatory analysis. High levels of metals in a sample can cause arcing in the microwave oven, and sometimes slag forms in the sample. Microwave oven drying can also melt plastic containers used to hold the sample.

11.6 The homogenized dried sample material should be ground with a mortar and pestle and passed through a 60-mesh sieve to achieve a uniform particle size. Sample grinding should continue until at least 90 percent of the original sample passes through the sieve. The grinding step normally takes an average of 10 min per sample. An aliquot of the sieved sample should then be placed in a 31.0-mm polyethylene sample cup (or equivalent) for analysis. The sample cup should be one-half to three-quarters full at a minimum. The sample cup should be covered with a 2.5 μm Mylar (or equivalent) film for analysis. The rest of the soil sample should be placed in a jar, labeled, and archived for possible confirmation analysis. All equipment including the mortar, pestle, and sieves must be thoroughly cleaned so that any cross-contamination is below the established lower limit of detection of the procedure or DQOs of the analysis. If all recommended sample preparation steps are followed, there is a high probability the desired laboratory data quality may be obtained.

12.0 DATA ANALYSIS AND CALCULATIONS

Most FPXRF instruments have software capable of storing all analytical results and spectra. The results are displayed in ppm and can be downloaded to a personal computer, which can be used to provide a hard copy printout. Individual measurements that are smaller than three times their associated SD should not be used for quantitation. See the manufacturer's instructions regarding data analysis and calculations.

13.0 METHOD PERFORMANCE

13.1 Performance data and related information are provided in SW-846 methods only as examples and guidance. The data do not represent required performance criteria for users of the methods. Instead, performance criteria should be developed on a project-specific basis, and the laboratory should establish in-house QC performance criteria for the application of this method. These performance data are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

13.2 The sections to follow discuss three performance evaluation factors; namely, precision, accuracy, and comparability. The example data presented in Tables 4 through 8 were generated from results obtained from six FPXRF instruments (see Sec. 13.3). The soil samples analyzed by the six FPXRF instruments were collected from two sites in the United States. The soil samples contained several of the target analytes at concentrations ranging from "nondetect" to tens of thousands of mg/kg. These data are provided for guidance purposes only.

13.3 The six FPXRF instruments included the TN 9000 and TN Lead Analyzer manufactured by TN Spectrace; the X-MET 920 with a SiLi detector and X-MET 920 with a gas-filled proportional detector manufactured by Metorex, Inc.; the XL Spectrum Analyzer manufactured by Niton; and the MAP Spectrum Analyzer manufactured by Scitec. The TN 9000 and TN Lead Analyzer both have a Hgl_2 detector. The TN 9000 utilized an Fe-55, Cd-109, and Am-241 source. The TN Lead Analyzer had only a Cd-109 source. The X-Met 920 with the SiLi detector had a Cd-109 and Am-241 source. The X-MET 920 with the gas-filled proportional detector had only a Cd-109 source. The XL Spectrum Analyzer utilized a silicon pin-diode

detector and a Cd-109 source. The MAP Spectrum Analyzer utilized a solid-state silicon detector and a Cd-109 source.

13.4 All example data presented in Tables 4 through 8 were generated using the following calibrations and source count times. The TN 9000 and TN Lead Analyzer were calibrated using fundamental parameters using NIST SRM 2710 as a calibration check sample. The TN 9000 was operated using 100, 60, and 60 second count times for the Cd-109, Fe-55, and Am-241 sources, respectively. The TN Lead analyzer was operated using a 60 second count time for the Cd-109 source. The X-MET 920 with the Si(Li) detector was calibrated using fundamental parameters and one well characterized site-specific soil standard as a calibration check. It used 140 and 100 second count times for the Cd-109 and Am-241 sources, respectively. The X-MET 920 with the gas-filled proportional detector was calibrated empirically using between 10 and 20 well characterized site-specific soil standards. It used 120 second times for the Cd-109 source. The XL Spectrum Analyzer utilized NIST SRM 2710 for calibration and the Compton peak normalization procedure for quantitation based on 60 second count times for the Cd-109 source. The MAP Spectrum Analyzer was internally calibrated by the manufacturer. The calibration was checked using a well-characterized site-specific soil standard. It used 240 second times for the Cd-109 source.

13.5 Precision measurements -- The example precision data are presented in Table 4. These data are provided for guidance purposes only. Each of the six FPXRF instruments performed 10 replicate measurements on 12 soil samples that had analyte concentrations ranging from "nondetects" to thousands of mg/kg. Each of the 12 soil samples underwent 4 different preparation techniques from in situ (no preparation) to dried and ground in a sample cup. Therefore, there were 48 precision data points for five of the instruments and 24 precision points for the MAP Spectrum Analyzer. The replicate measurements were taken using the source count times discussed at the beginning of this section.

For each detectable analyte in each precision sample a mean concentration, standard deviation, and RSD was calculated for each analyte. The data presented in Table 4 is an average RSD for the precision samples that had analyte concentrations at 5 to 10 times the lower limit of detection for that analyte for each instrument. Some analytes such as mercury, selenium, silver, and thorium were not detected in any of the precision samples so these analytes are not listed in Table 4. Some analytes such as cadmium, nickel, and tin were only detected at concentrations near the lower limit of detection so that an RSD value calculated at 5 to 10 times this limit was not possible.

One FPXRF instrument collected replicate measurements on an additional nine soil samples to provide a better assessment of the effect of sample preparation on precision. Table 5 shows these results. These data are provided for guidance purposes only. The additional nine soil samples were comprised of three from each texture and had analyte concentrations ranging from near the lower limit of detection for the FPXRF analyzer to thousands of mg/kg. The FPXRF analyzer only collected replicate measurements from three of the preparation methods; no measurements were collected from the in situ homogenized samples. The FPXRF analyzer conducted five replicate measurements of the in situ field samples by taking measurements at five different points within the 4-inch by 4-inch sample square. Ten replicate measurements were collected for both the intrusive undried and unground and intrusive dried and ground samples contained in cups. The cups were shaken between each replicate measurement.

Table 5 shows that the precision dramatically improved from the in situ to the intrusive measurements. In general there was a slight improvement in precision when the sample was dried and ground. Two factors caused the precision for the in situ measurements to be poorer. The major factor is soil heterogeneity. By moving the probe within the 4-inch by 4-inch square,

measurements of different soil samples were actually taking place within the square. Table 5 illustrates the dominant effect of soil heterogeneity. It overwhelmed instrument precision when the FPXRF analyzer was used in this mode. The second factor that caused the RSD values to be higher for the in situ measurements is the fact that only five instead of ten replicates were taken. A lesser number of measurements caused the standard deviation to be larger which in turn elevated the RSD values.

13.6 Accuracy measurements -- Five of the FPXRF instruments (not including the MAP Spectrum Analyzer) analyzed 18 SRMs using the source count times and calibration methods given at the beginning of this section. The 18 SRMs included 9 soil SRMs, 4 stream or river sediment SRMs, 2 sludge SRMs, and 3 ash SRMs. Each of the SRMs contained known concentrations of certain target analytes. A percent recovery was calculated for each analyte in each SRM for each FPXRF instrument. Table 6 presents a summary of this data. With the exception of cadmium, chromium, and nickel, the values presented in Table 6 were generated from the 13 soil and sediment SRMs only. The 2 sludge and 3 ash SRMs were included for cadmium, chromium, and nickel because of the low or nondetectable concentrations of these three analytes in the soil and sediment SRMs.

Only 12 analytes are presented in Table 6. These are the analytes that are of environmental concern and provided a significant number of detections in the SRMs for an accuracy assessment. No data is presented for the X-MET 920 with the gas-filled proportional detector. This FPXRF instrument was calibrated empirically using site-specific soil samples. The percent recovery values from this instrument were very sporadic and the data did not lend itself to presentation in Table 6.

Table 7 provides a more detailed summary of accuracy data for one particular FPXRF instrument (TN 9000) for the 9 soil SRMs and 4 sediment SRMs. These data are provided for guidance purposes only. Table 7 shows the certified value, measured value, and percent recovery for five analytes. These analytes were chosen because they are of environmental concern and were most prevalently certified for in the SRM and detected by the FPXRF instrument. The first nine SRMs are soil and the last 4 SRMs are sediment. Percent recoveries for the four NIST SRMs were often between 90 and 110 percent for all analytes.

13.7 Comparability -- Comparability refers to the confidence with which one data set can be compared to another. In this case, FPXRF data generated from a large study of six FPXRF instruments was compared to SW-846 Methods 3050 and 6010 which are the standard soil extraction for metals and analysis by inductively coupled plasma. An evaluation of comparability was conducted by using linear regression analysis. Three factors were determined using the linear regression. These factors were the y-intercept, the slope of the line, and the coefficient of determination (r^2).

As part of the comparability assessment, the effects of soil type and preparation methods were studied. Three soil types (textures) and four preparation methods were examined during the study. The preparation methods evaluated the cumulative effect of particle size, moisture, and homogenization on comparability. Due to the large volume of data produced during this study, linear regression data for six analytes from only one FPXRF instrument is presented in Table 8. Similar trends in the data were seen for all instruments. These data are provided for guidance purposes only.

Table 8 shows the regression parameters for the whole data set, broken out by soil type, and by preparation method. These data are provided for guidance purposes only. The soil types are as follows: soil 1--sand; soil 2--loam; and soil 3--silty clay. The preparation methods are as follows: preparation 1--in situ in the field; preparation 2--intrusive, sample collected and homogenized; preparation 3--intrusive, with sample in a sample cup but sample still wet and not

ground; and preparation 4—intrusive, with sample dried, ground, passed through a 40-mesh sieve; and placed in sample cup.

For arsenic, copper, lead, and zinc, the comparability to the confirmatory laboratory was excellent with r^2 values ranging from 0.80 to 0.99 for all six FPXRF instruments. The slopes of the regression lines for arsenic, copper, lead, and zinc, were generally between 0.90 and 1.00 indicating the data would need to be corrected very little or not at all to match the confirmatory laboratory data. The r^2 values and slopes of the regression lines for barium and chromium were not as good as for the other for analytes, indicating the data would have to be corrected to match the confirmatory laboratory.

Table 8 demonstrates that there was little effect of soil type on the regression parameters for any of the six analytes. The only exceptions were for barium in soil 1 and copper in soil 3. In both of these cases, however, it is actually a concentration effect and not a soil effect causing the poorer comparability. All barium and copper concentrations in soil 1 and 3, respectively, were less than 350 mg/kg.

Table 8 shows there was a preparation effect on the regression parameters for all six analytes. With the exception of chromium, the regression parameters were primarily improved going from preparation 1 to preparation 2. In this step, the sample was removed from the soil surface, all large debris was removed, and the sample was thoroughly homogenized. The additional two preparation methods did little to improve the regression parameters. This data indicates that homogenization is the most critical factor when comparing the results. It is essential that the sample sent to the confirmatory laboratory match the FPXRF sample as closely as possible.

Sec. 11.0 of this method discusses the time necessary for each of the sample preparation techniques. Based on the data quality objectives for the project, an analyst must decide if it is worth the extra time necessary to dry and grind the sample for small improvements in comparability. Homogenization requires 3 to 5 min. Drying the sample requires one to two hours. Grinding and sieving requires another 10 to 15 min per sample. Lastly, when grinding and sieving is conducted, time has to be allotted to decontaminate the mortars, pestles, and sieves. Drying and grinding the samples and decontamination procedures will often dictate that an extra person be on site so that the analyst can keep up with the sample collection crew. The cost of requiring an extra person on site to prepare samples must be balanced with the gain in data quality and sample throughput.

13.8 The following documents may provide additional guidance and insight on this method and technique:

13.8.1 A. D. Hewitt, "Screening for Metals by X-ray Fluorescence Spectrometry/Response Factor/Compton K_α Peak Normalization Analysis," American Environmental Laboratory, pp 24-32, 1994.

13.8.2 S. Piorek and J. R. Pasmore, "Standardless, In Situ Analysis of Metallic Contaminants in the Natural Environment With a PC-Based, High Resolution Portable X-Ray Analyzer," Third International Symposium on Field Screening Methods for Hazardous Waste and Toxic Chemicals, Las Vegas, Nevada, February 24-26, 1993, Vol 2, pp 1135-1151, 1993.

13.8.3 S. Shefsky, "Sample Handling Strategies for Accurate Lead-in-soil Measurements in the Field and Laboratory," *International Symposium of Field Screening Methods for Hazardous Waste and Toxic Chemicals*, Las Vegas, NV, January 29-31, 1997.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity and/or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

14.2 For information about pollution prevention that may be applicable to laboratories and research institutions consult *Less is Better: Laboratory Chemical Management for Waste Reduction* available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th St., N.W. Washington, D.C. 20036, <http://www.acs.org>.

15.0 WASTE MANAGEMENT

The Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any sewer discharge permits and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management, consult *The Waste Management Manual for Laboratory Personnel* available from the American Chemical Society at the address listed in Sec. 14.2.

16.0 REFERENCES

1. Metorex, X-MET 920 User's Manual.
2. Spectrace Instruments, "Energy Dispersive X-ray Fluorescence Spectrometry: An Introduction," 1994.
3. TN Spectrace, Spectrace 9000 Field Portable/Benchtop XRF Training and Applications Manual.
4. Unpublished SITE data, received from PRC Environment Management, Inc.

17.0 TABLES, DIAGRAMS, FLOWCHARTS, AND VALIDATION DATA

The following pages contain the tables referenced by this method. A flow diagram of the procedure follows the tables.

TABLE 1

EXAMPLE INTERFERENCE FREE LOWER LIMITS OF DETECTION

Analyte	Chemical Abstract Series Number	Lower Limit of Detection in Quartz Sand (milligrams per kilogram)
Antimony (Sb)	7440-36-0	40
Arsenic (As)	7440-38-0	40
Barium (Ba)	7440-39-3	20
Cadmium (Cd)	7440-43-9	100
Calcium (Ca)	7440-70-2	70
Chromium (Cr)	7440-47-3	150
Cobalt (Co)	7440-48-4	60
Copper (Cu)	7440-50-8	50
Iron (Fe)	7439-89-6	60
Lead (Pb)	7439-92-1	20
Manganese (Mn)	7439-96-5	70
Mercury (Hg)	7439-97-6	30
Molybdenum (Mo)	7439-93-7	10
Nickel (Ni)	7440-02-0	50
Potassium (K)	7440-09-7	200
Rubidium (Rb)	7440-17-7	10
Selenium (Se)	7782-49-2	40
Silver (Ag)	7440-22-4	70
Strontium (Sr)	7440-24-6	10
Thallium (Tl)	7440-28-0	20
Thorium (Th)	7440-29-1	10
Tin (Sn)	7440-31-5	60
Titanium (Ti)	7440-32-6	50
Vanadium (V)	7440-62-2	50
Zinc (Zn)	7440-66-6	50
Zirconium (Zr)	7440-67-7	10

Source: Refs. 1, 2, and 3

These data are provided for guidance purposes only.

TABLE 2

SUMMARY OF RADIOISOTOPE SOURCE CHARACTERISTICS

Source	Activity (mCi)	Half-Life (Years)	Excitation Energy (keV)	Elemental Analysis Range	
Fe-55	20-50	2.7	5.9	Sulfur to Chromium Molybdenum to Barium	K Lines L Lines
Cd-109	5-30	1.3	22.1 and 87.9	Calcium to Rhodium Tantalum to Lead Barium to Uranium	K Lines K Lines L Lines
Am-241	5-30	432	26.4 and 59.6	Copper to Thulium Tungsten to Uranium	K Lines L Lines
Cm-244	60-100	17.8	14.2	Titanium to Selenium Lanthanum to Lead	K Lines L Lines

Source: Refs. 1, 2, and 3

TABLE 3

SUMMARY OF X-RAY TUBE SOURCE CHARACTERISTICS

Anode Material	Recommended Voltage Range (kV)	K-alpha Emission (keV)	Elemental Analysis Range	
Cu	18-22	8.04	Potassium to Cobalt Silver to Gadolinium	K Lines L Lines
Mo	40-50	17.4	Cobalt to Yttrium Europium to Radon	K Lines L Lines
Ag	50-65	22.1	Zinc to Technicium Ytterbium to Neptunium	K Lines L Lines

Source: Ref. 4

Notes: The sample elements excited are chosen by taking as the lower limit the same ratio of excitation line energy to element absorption edge as in Table 2 (approximately 0.45) and the requirement that the excitation line energy be above the element absorption edge as the upper limit (L2 edges used for L lines). K-beta excitation lines were ignored.

TABLE 4

EXAMPLE PRECISION VALUES

Analyte	Average Relative Standard Deviation for Each Instrument at 5 to 10 Times the Lower Limit of Detection					
	TN 9000	TN Lead Analyzer	X-MET 920 (SiLi Detector)	X-MET 920 (Gas-Filled Detector)	XL Spectrum Analyzer	MAP Spectrum Analyzer
Antimony	6.54	NR	NR	NR	NR	NR
Arsenic	5.33	4.11	3.23	1.91	12.47	6.68
Barium	4.02	NR	3.31	5.91	NR	NR
Cadmium	29.84 ^a	NR	24.80 ^a	NR	NR	NR
Calcium	2.16	NR	NR	NR	NR	NR
Chromium	22.25	25.78	22.72	3.91	30.25	NR
Cobalt	33.90	NR	NR	NR	NR	NR
Copper	7.03	9.11	8.49	9.12	12.77	14.86
Iron	1.78	1.67	1.55	NR	2.30	NR
Lead	6.45	5.93	5.05	7.56	6.97	12.16
Manganese	27.04	24.75	NR	NR	NR	NR
Molybdenum	6.95	NR	NR	NR	12.60	NR
Nickel	30.85 ^a	NR	24.92 ^a	20.92 ^a	NA	NR
Potassium	3.90	NR	NR	NR	NR	NR
Rubidium	13.06	NR	NR	NR	32.69 ^a	NR
Strontium	4.28	NR	NR	NR	8.86	NR
Tin	24.32 ^a	NR	NR	NR	NR	NR
Titanium	4.87	NR	NR	NR	NR	NR
Zinc	7.27	7.48	4.26	2.28	10.95	0.83
Zirconium	3.58	NR	NR	NR	6.49	NR

These data are provided for guidance purposes only.

Source: Ref. 4

^a These values are biased high because the concentration of these analytes in the soil samples was near the lower limit of detection for that particular FPXRF instrument.

NR Not reported.

NA Not applicable; analyte was reported but was below the established lower limit detection.

TABLE 5

EXAMPLES OF PRECISION AS AFFECTED BY SAMPLE PREPARATION

Analyte	Average Relative Standard Deviation for Each Preparation Method		
	In Situ-Field	Intrusive- Undried and Unground	Intrusive- Dried and Ground
Antimony	30.1	15.0	14.4
Arsenic	22.5	5.36	3.76
Barium	17.3	3.38	2.90
Cadmium ^a	41.2	30.8	28.3
Calcium	17.5	1.68	1.24
Chromium	17.6	28.5	21.9
Cobalt	28.4	31.1	28.4
Copper	26.4	10.2	7.90
Iron	10.3	1.67	1.57
Lead	25.1	8.55	6.03
Manganese	40.5	12.3	13.0
Mercury	ND	ND	ND
Molybdenum	21.6	20.1	19.2
Nickel ^a	29.8	20.4	18.2
Potassium	18.6	3.04	2.57
Rubidium	29.8	16.2	18.9
Selenium	ND	20.2	19.5
Silver ^a	31.9	31.0	29.2
Strontium	15.2	3.38	3.98
Thallium	39.0	16.0	19.5
Thorium	NR	NR	NR
Tin	ND	14.1	15.3
Titanium	13.3	4.15	3.74
Vanadium	NR	NR	NR
Zinc	26.6	13.3	11.1
Zirconium	20.2	5.63	5.18

These data are provided for guidance purposes only.

Source: Ref. 4

^a These values may be biased high because the concentration of these analytes in the soil samples was near the lower limit of detection.

ND Not detected.

NR Not reported.

TABLE 6
EXAMPLE ACCURACY VALUES

Analyte	Instrument															
	TN 9000				TN Lead Analyzer				X-MET 920 (SiLi Detector)				XL Spectrum Analyzer			
	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD
Sb	2	100-149	124.3	NA	--	--	--	--	--	--	--	--	--	--	--	--
As	5	68-115	92.8	17.3	5	44-105	83.4	23.2	4	9.7-91	47.7	39.7	5	38-535	189.8	206
Ba	9	98-198	135.3	36.9	--	--	--	--	9	18-848	168.2	262	--	--	--	--
Cd	2	99-129	114.3	NA	--	--	--	--	6	81-202	110.5	45.7	--	--	--	--
Cr	2	99-178	138.4	NA	--	--	--	--	7	22-273	143.1	93.8	3	98-625	279.2	300
Cu	8	61-140	95.0	28.8	6	38-107	79.1	27.0	11	10-210	111.8	72.1	8	95-480	203.0	147
Fe	6	78-155	103.7	26.1	6	89-159	102.3	28.6	6	48-94	80.4	16.2	6	26-187	108.6	52.9
Pb	11	66-138	98.9	19.2	11	68-131	97.4	18.4	12	23-94	72.7	20.9	13	80-234	107.3	39.9
Mn	4	81-104	93.1	9.70	3	92-152	113.1	33.8	--	--	--	--	--	--	--	--
Ni	3	99-122	109.8	12.0	--	--	--	--	--	--	--	--	3	57-123	87.5	33.5
Sr	8	110-178	132.6	23.8	--	--	--	--	--	--	--	--	7	86-209	125.1	39.5
Zn	11	41-130	94.3	24.0	10	81-133	100.0	19.7	12	46-181	106.6	34.7	11	31-199	94.6	42.5

Source: Ref. 4. These data are provided for guidance purposes only.

n: Number of samples that contained a certified value for the analyte and produced a detectable concentration from the FPXRF instrument.

SD: Standard deviation; NA: Not applicable; only two data points, therefore, a SD was not calculated.

%Rec.: Percent recovery.

-- No data.

TABLE 7

EXAMPLE ACCURACY FOR TN 9000^a

Standard Reference Material	Arsenic			Barium			Copper			Lead			Zinc		
	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.
RTC CRM-021	24.8	ND	NA	586	1135	193.5	4792	2908	60.7	144742	149947	103.6	546	224	40.9
RTC CRM-020	397	429	92.5	22.3	ND	NA	753	583	77.4	5195	3444	66.3	3022	3916	129.6
BCR CRM 143R	--	--	--	--	--	--	131	105	80.5	180	206	114.8	1055	1043	99.0
BCR CRM 141	--	--	--	--	--	--	32.6	ND	NA	29.4	ND	NA	81.3	ND	NA
USGS GXR-2	25.0	ND	NA	2240	2946	131.5	76.0	106	140.2	690	742	107.6	530	596	112.4
USGS GXR-6	330	294	88.9	1300	2581	198.5	66.0	ND	NA	101	80.9	80.1	118	ND	NA
NIST 2711	105	104	99.3	726	801	110.3	114	ND	NA	1162	1172	100.9	350	333	94.9
NIST 2710	626	722	115.4	707	782	110.6	2950	2834	96.1	5532	5420	98.0	6952	6476	93.2
NIST 2709	17.7	ND	NA	968	950	98.1	34.6	ND	NA	18.9	ND	NA	106	98.5	93.0
NIST 2704	23.4	ND	NA	414	443	107.0	98.6	105	106.2	161	167	103.5	438	427	97.4
CNRC PACS-1	211	143	67.7	--	772	NA	452	302	66.9	404	332	82.3	824	611	74.2
SARM-51	--	--	--	335	466	139.1	268	373	139.2	5200	7199	138.4	2200	2676	121.6
SARM-52	--	--	--	410	527	128.5	219	193	88.1	1200	1107	92.2	264	215	81.4

Source: Ref. 4. These data are provided for guidance purposes only.

^a All concentrations in milligrams per kilogram.

%Rec.: Percent recovery; ND: Not detected; NA: Not applicable.

-- No data.

TABLE 8

EXAMPLE REGRESSION PARAMETERS FOR COMPARABILITY¹

	Arsenic				Barium				Copper			
	n	r ²	Int.	Slope	n	r ²	Int.	Slope	n	r ²	Int.	Slope
All Data	824	0.94	1.62	0.94	1255	0.71	60.3	0.54	984	0.93	2.19	0.93
Soil 1	368	0.96	1.41	0.95	393	0.05	42.6	0.11	385	0.94	1.26	0.99
Soil 2	453	0.94	1.51	0.96	462	0.56	30.2	0.66	463	0.92	2.09	0.95
Soil 3	—	—	—	—	400	0.85	44.7	0.59	136	0.46	16.60	0.57
Prep 1	207	0.87	2.69	0.85	312	0.64	53.7	0.55	256	0.87	3.89	0.87
Prep 2	208	0.97	1.38	0.95	315	0.67	64.6	0.52	246	0.96	2.04	0.93
Prep 3	204	0.96	1.20	0.99	315	0.78	64.6	0.53	236	0.97	1.45	0.99
Prep 4	205	0.96	1.45	0.98	313	0.81	58.9	0.55	246	0.96	1.99	0.96

	Lead				Zinc				Chromium			
	n	r ²	Int.	Slope	n	r ²	Int.	Slope	n	r ²	Int.	Slope
All Data	1205	0.92	1.66	0.95	1103	0.89	1.86	0.95	280	0.70	64.6	0.42
Soil 1	357	0.94	1.41	0.96	329	0.93	1.78	0.93	—	—	—	—
Soil 2	451	0.93	1.62	0.97	423	0.85	2.57	0.90	—	—	—	—
Soil 3	397	0.90	2.40	0.90	351	0.90	1.70	0.98	186	0.66	38.9	0.50
Prep 1	305	0.80	2.88	0.86	286	0.79	3.16	0.87	105	0.80	66.1	0.43
Prep 2	298	0.97	1.41	0.96	272	0.95	1.86	0.93	77	0.51	81.3	0.36
Prep 3	302	0.98	1.26	0.99	274	0.93	1.32	1.00	49	0.73	53.7	0.45
Prep 4	300	0.96	1.38	1.00	271	0.94	1.41	1.01	49	0.75	31.6	0.56

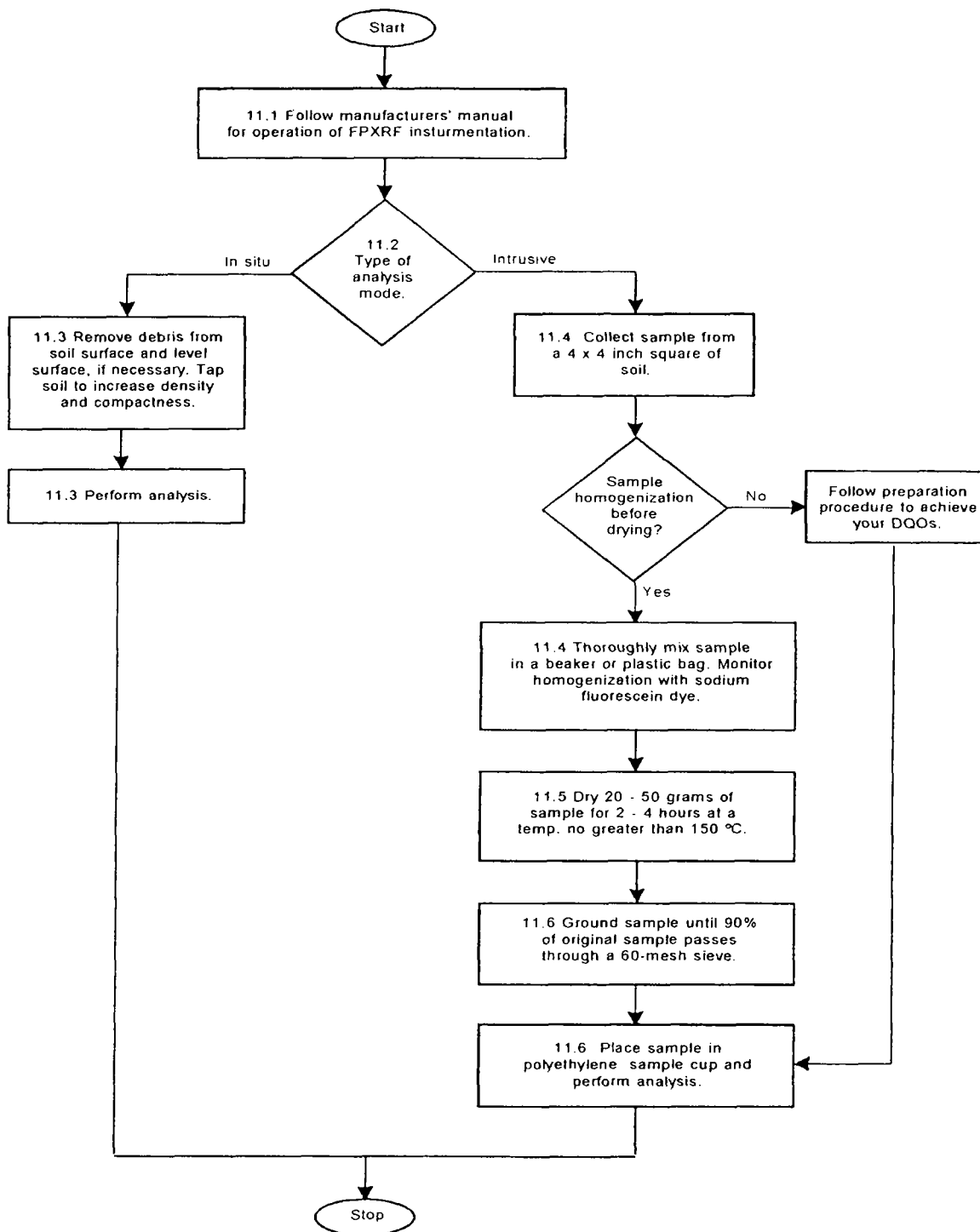
Source: Ref. 4. These data are provided for guidance purposes only.

¹ Log-transformed data

n: Number of data points; r²: Coefficient of determination; Int.: Y-intercept

— No applicable data

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE
DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT



ARCADIS

Appendix C

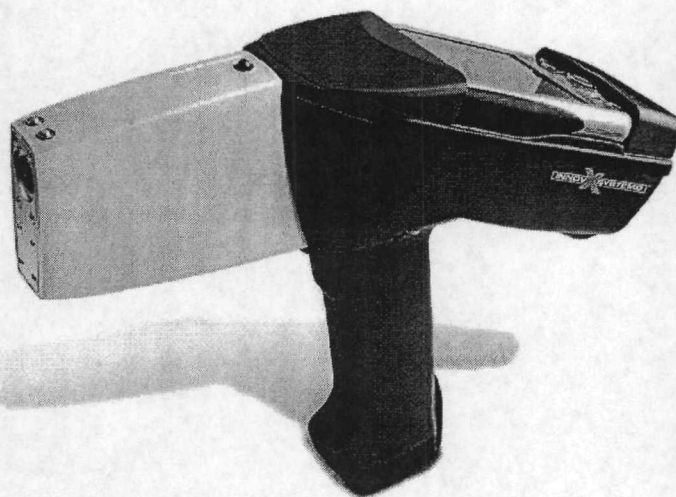
Innov-X Alpha Series Specification
Sheet

Alpha Series™

analyzers provide on-site environmental metals testing.

For point-and-shoot simplicity Innov-X offers the smallest, fastest and most versatile handheld XRF analyzer available.

The Innov-X tube-based Alpha Series™ takes on-site environmental metals analysis to a new level. It features a miniature, rugged X-ray tube. The Alpha Series™ provides reliable analysis on RCRA, Priority Pollutant metals and other elements in soils, liquids, coatings, etc. Meets EPA Method 6200 for metals in soils, NIOSH Method 7702 for lead in air filters, OSHA Methods OSS1 and OSA1 for lead in surface wipes and air filters.

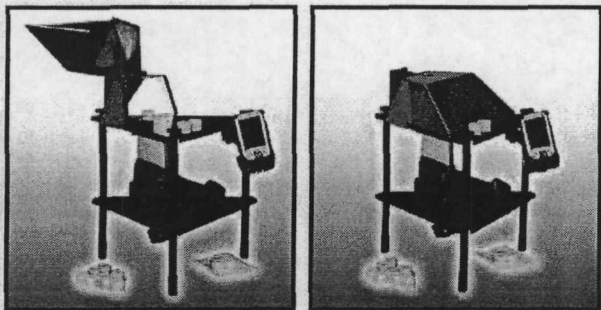


The Alpha Series™ identifies toxic metals, RCRA and other pollutants in a variety of samples.

A summary of its testing capabilities:

- RCRA and Priority Pollutant metals analysis in a wide variety of samples.
- Metals in soil.
- Lead-based paint.
- Filter media.
- Dust wipe analysis.
- CCA (Chromated Copper Arsenate) treated wood, other construction materials or debris.
- Paints & coatings, hazardous waste classification, oils and liquids.

2	2	80	2	48	2	35
Pb	8	Hg	8	Cd	8	B
Lead	18	Mercury	18	Cadmium	18	Br
207.2	32	200.59	32	112.411	2	79.
	18		18			
	4		2			



Docking station/test stand with safety cover for analysis of bagged and prepared samples.



Innovative XRF Technologies

Innov-X Alpha Series™

The environmental analyzer for on-site, fast, confident screening of pollutants.



Rely on the Alpha Series™ for a wide variety of on-site environmental analyses. These include in-situ soil analysis for rapid site investigations and remediation projects. Operators may test directly on the ground or through bagged samples. By collecting and preparing soil samples you can achieve laboratory quality results in the field. The Alpha Series™ can be pre-calibrated for filters, coatings, CCA-treated wood and many other sample types.

The PDA Advantage.

The Alpha Series™ is driven by the HP IPAQ pocket PC.

- Upgrade to new generations as available.
- Use different PDAs and preserve personal settings.
- Wireless data transfer – ideal for remote sites.
- Easily transfer data or download software and upgrades.



Custom holster lets you take Alpha Series™ anywhere.



Bluetooth enabled PDA for remote display, printing and data transfer.

State-of-the-Art Technology.

Innov-X combines an X-ray tube source, multiple beam filtering and the HP PDA to deliver superior limits of detection, speed, precision and upgrade capability.

- Superior performance on Cr and other metals. Light Element Analysis Program (LEAP) analyzes P, S, Cl, K and Ca.

- Utilizes advanced and universal XRF data modeling:

Compton Normalization: "Internal Standard" provides for quantitative analysis without site-specific calibrations.

Fundamental Parameters: Standardless, ideal for samples with high and low concentrations of several elements.

Empirical Calibrations: "Calibration Curves", allows user-generated calibration curves.

- Add new elements and calibrations easily. Innov-X analyzers will meet your requirements today and in the future.
- View spectra on screen.
- Compare spectra for comparative analysis and display results versus standards.
- Stored tests can be re-run with new parameters or models.
- Data Security: stored in binary format for data integrity.

Basic Specifications.

Weight: 2.625 lbs. (base wt.) 3.375 lbs (1.6 kg) with batteries.

Excitation Source: X-ray tube, W anode, 10-40 kV, 10-50 µA, up to 5 selectable filters.

LEAP: Delivers industry-leading detection limits on critical elements Cr, Cl, P, Ba, Ti, S, Ca, K.

Detector: Si PiN diode detector, < 230 eV FWHM at 5.95 keV Mn K-alpha line. Temperature Range: -10°C to +50°C.

Operation: Trigger or Start/Stop Icon. One-touch trigger or "deadman" trigger option. Optional control from external PC.

Power: Li-ion batteries, rechargeable (charger included). Powers analyzer and iPAQ simultaneously. AC Adapter optional.

Battery Life: 8 hours (typical duty cycle) using built-in, optional multiple battery pack.

Number of Elements: Standard package includes 20 elements.

Standard Elements: Pb, Cr, Hg, Cd, Sb, Ti, Mn, Fe, Ni, Cu, Zn, Sn, Ag, As, Se, Ba, Co, Zr, Rb. Common additions: W, Br, Tl.

Display Screen: Color, high resolution touchscreen. Variable brightness provides easy viewing in all ambient lighting conditions.

Data Display: Concentrations in ppm, spectra, peak intensities (count rate) or user-specified units, depending on software mode selected.

Memory, Data Storage: 128 Mb standard memory. 20,000 test results with spectra, upgrade to >100,000 with optional 1 Gb flash card.

Processor: Intel 400 MHz StrongArm processor or higher.

Operating System: Microsoft Windows CE (portable system) or Windows (PC-based). Software Modes: Soil, Filter/Wipes, Empirical. Others available upon request.

Specifications subject to change without notice.



24	25	26	27	28	29	30	31	32
Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge
Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium
52.00	54.94	55.85	58.93	58.69	63.55	65.38	69.72	72.64

Innov-X Systems, Inc., Worldwide Headquarters, Woburn, MA USA (781) 938-5005 (866) 4-Innov-X www.Innov-Xsys.com

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6-05

ARCADIS

Appendix D

ARCADIS Health and Safety Plan

Health and Safety Plan

Client Name: United States Coast
Guard Civil Engineering Unit Cleveland

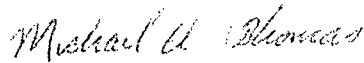
Project Name: United States Coast
Guard Old Station Ludington

Date: July 2008

ARCADIS



Lauren Edwards
Designated H&S Plan Writer



Designated H&S Plan Reviewer



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Senior Geologist

Health and Safety Plan

United States Coast Guard
Old Station Ludington

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Our Ref.:
DE000122.0001

Date:
July 16, 2008

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I	Lead Policy and Procedure

1. Introduction

All work on this project will be carried out in compliance with ARCADIS' Health and Safety Manual and the Occupational Safety and Health Administration's Hazardous Waste Operations and Emergency Response regulation 29 CFR 1910.120. Specific safety information for the project is contained in this Health and Safety Plan (HASP). All personnel working on hazardous operations or in the area of hazardous operations shall read and be familiar with this HASP before doing any work. All project personnel shall sign the certification page acknowledging that they have read and understand this HASP.

Changes in the scope of the project or introduction of new hazards to the project shall require revision of the HASP by the HASP writer and reviewer, and approval by the Project Manager. The HASP Addendum Form is included as Appendix A.

Addendums are to be added to every copy of the HASP, and logged in the following table to verify that all copies of the HASP are current:

Addendum Number	Date of Addendum	Reason for Addendum	Person Completing Addendum
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

2. Project Description

2.1 Project Dates

Projected Start Date: 9/8/08

Projected End Date: Open

2.2 Site Background

The Site is located at 101 South Lakeshore, Ludington, Michigan, in a residential area of the City of Ludington, Mason County. To the north of the Site is City of Ludington property used for park space and a boat launch, and South Lakeshore Drive ends at the Site. To the northeast of the Site is a multi-family apartment/condo development. To the east of the Site is the Starboard Tack Condominium complex. To the south of the Site is the current boat storage well used by the United States Coast Guard, and The Pere Marquette Lake channel which flows west into Lake Michigan. To the west of the Site is the new operating United States Coast Guard Station and a small storage garage.

The Site is currently occupied by the former United States Coast Guard station building. The building is currently vacant and being used for miscellaneous storage. The ground floor of the building was being used as a garage for miscellaneous storage. The garage was formerly used for the storage of boats and has a sloped floor which allowed for the drainage of water from the boats which were winched into the building on a rail system from the boat well to the south of the building. There is no evidence of the former rail system for the storage of the boats and the doors on the south side of the building were all removed and closed in. The remaining portions of the ground floor of the building were used for storage of equipment, an exercise room, and boiler room.

The main floor of the building was used for office, kitchen, and dining room. The second floor of the building was used for bedrooms, restrooms and storage space. The third floor/attic appeared to have been used for the storage of staff personal items.

2.3 List of Project Tasks and Scope of Work

Task 1 – Archaeological Survey. Prior to any drilling or earth moving activities at the Site, an archaeological survey will need to be conducted at the Site. ARCADIS will retain a subcontractor to conduct a Phase 1 Archaeological Survey in accordance with the Section 106 of the National Historical Preservation Act of 1996 (16 U.S. Code 470) and in compliance with 36 CFR 800.4 “Identification of Historic Properties”. The survey will consist of the following tasks:

- Conduct background research of the Site.
- Complete shovel test pits to approximately 1.5 feet to 2 feet below ground surface.
- Screen and inspect soil for artifacts
- Prepare a technical report for submittal to the State Historical Preservation Office (SHPO) for review and comment.

The survey will be conducted prior to the Site Investigation and supplemented if necessary prior to any potential removal actions. The survey activities at the site will be conducted in level D personal protective equipment. ARCADIS will provide oversight during the survey activities, which are anticipated to take two days to complete.

Task 2 – Lead in Soil Investigation. Lead impacts to soil are potentially present as a result of flaking/peeling of lead based exterior building paint. The investigation to evaluate the lateral and vertical extent of lead in soil will consist of collecting soil samples using a biased sampling strategy.

Surface soil samples will be collected at approximately 1 to 2 feet from the exterior building walls, at an average spacing of approximately 1 sample per 25 linear feet. No soil samples will be collected from beneath concrete or asphaltic surfaces. Based on the layout of the grounds and the size of the former station building, ARCADIS estimates that initially nine locations will be sampled. The final location and number of samples will be determined in the field based on observations of the soil surrounding the building and the condition of the building.

Soil samples will be collected from the surface soils (0-6 inches below ground surface) in areas adjacent to the former station building at the Site where lead impacts from

flaking/peeling paint are likely to be encountered. These samples will be field screened using an XRF Analyzer. If the field-screening results indicate the potential for impacts, ARCADIS will collect subsurface soil samples from subsequent depth intervals at the same location and screen the samples using XRF for vertical delineation. Once the field screening indicates lead impacts below the target screening concentration specified in the FSP, vertical delineation samples will be collected and submitted for laboratory analysis. ARCADIS estimates that a maximum of five subsurface soil samples will be collected and submitted for laboratory analysis.

Additional step-out samples will be collected and field screened using the XRF analyzer to determine the lateral extent of lead impacts from the exterior building surfaces. Step-out samples will be collected approximately 5 feet from the initial samples and will continue at approximately 5 foot intervals until results of the XRF field screening are less than 100 mg/kg. The outermost step-out samples from Site structures will be collected and submitted for laboratory analysis.

Three background soil samples will be collected from depth intervals comparable to samples collected during the biased Site evaluation sampling described above. The sample locations will be selected with respect to the prevailing wind direction, contain soils of similar composition and depositional origin to those throughout the Site, and are in a area believed not to be impacted by Site operations or other potential sources.

Task 3 – Monitoring Well Installation/Groundwater Sampling. To evaluate the potential for lead to leach from the lead-based exterior paint, ARCADIS will install a maximum of three 2-inch diameter groundwater monitoring wells and collect groundwater samples for laboratory analysis. Following installation, the wells will be developed and sampled using low-flow purge and sampling techniques in accordance with the QAPP and FSP. The samples will be collected from each well on a quarterly basis for one year (four sample events).

Task 4 – Geophysical Survey. ARCADIS understands that the status of the two USTs associated with the site (a diesel and used oil USTs) is unknown. One of the USTs was reportedly removed; however, there is no documentation of the removal activities or fuel piping abandonment, or if impacts were observed during the removal. Based on this information and the lack of documentation regarding the status of the other UST and fuel piping, ARCADIS will conduct a geophysical survey of the two areas where the USTs reportedly existed to determine if they are still in place. If the USTs are in place, ARCADIS will provide USCG with recommendations for removal

and assessment in accordance with the MDEQ-PRD Part 201 guidance for conducting site assessments.

Task 5 – UST Impact Delineation. If the results of the geophysical survey indicated that the USTs and associated piping have been removed or are not present, ARCADIS will complete a maximum of 12 soil borings to 15 feet below ground surface to characterize potential impacts to soil in the vicinity of the former USTs and former fuel piping. The final number and location of soil borings will be determined based on geophysical survey results and field observations.

ARCADIS will complete three of the soil borings as 2-inch diameter monitoring wells to characterize potential groundwater impacts, if field screening results indicate a petroleum hydrocarbon release is evident. Following installation, the wells will be developed and sampled using low-flow purge sampling techniques in accordance with the MDEQ-RRD Operational Memorandum 2. Groundwater samples will be collected from each monitoring well on a quarterly basis for one year (four sample events).

Task 6 – Investigation-Derived Waste (IDW) Management. At a minimum, ARCADIS anticipates generating soil cuttings, personal protective equipment (PPE) and decontamination and purge fluids during implementation of the field investigation. ALL IDW will be placed in steel Department of Transportation (DOT) approved 55-gallon drums and will be stored temporarily on the Site at location to be determined by USCG. All IDW drums will be properly labeled and dated to indicate the contents and origin of the materials. ARCADIS will coordinate soil and liquid waste characterization, manifesting, transportation, and off-site disposal within 60 days of the completion of the investigation activities.

2.4 Site Description

Site Type: (Check as many as applicable)

<input type="checkbox"/>	Active	<input type="checkbox"/>	Secure	<input checked="" type="checkbox"/>	Industrial	<input type="checkbox"/>	Landfill	<input type="checkbox"/>	Service station
<input checked="" type="checkbox"/>	Inactive	<input checked="" type="checkbox"/>	Unsecured	<input type="checkbox"/>	Commercial	<input type="checkbox"/>	Well field	<input type="checkbox"/>	Water work
<input type="checkbox"/>		<input type="checkbox"/>	Uncontrolled	<input type="checkbox"/>	Residential	<input type="checkbox"/>	Railroad	<input type="checkbox"/>	Undeveloped
<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	Other specify:				

Surrounding Population:

<input checked="" type="checkbox"/>	Residential	<input checked="" type="checkbox"/>	Industrial	<input type="checkbox"/>	Commercial	<input type="checkbox"/>	Rural	<input type="checkbox"/>	Other:
-------------------------------------	-------------	-------------------------------------	------------	--------------------------	------------	--------------------------	-------	--------------------------	--------

ARCADIS

Health and Safety Plan

United States Coast Guard
Old Station Ludington

Approximately 25 percent of the site is grass covered, with a wooded area encompassing the northwestern, northeastern, and southeastern sides of the site.

3. Hazard/Risk Analysis and Communication

3.1 Hazard Assessment and Risk Control (HARC)

Each hazard is evaluated and rated for the level of risk based on the task of the project. A thorough analysis of hazards and their risk is completed using the following HARC matrix:

Risk Assessment Matrix		Likelihood Ratings**				
Consequences Ratings*		A	B	C	D	E
People	Property	Never heard of in the world	Heard of incident in industry	Incident has occurred in ARCADIS Group	Happens several times a year in ARCADIS OpCo	Happens several times a year at ARCADIS Worksite
0 - No health effect	0 - No damage	Low	Low	Low	Low	Low
1 - Slight health effect	1 - Slight damage	Low	Low	Low	Low	Low
2 - Minor health effect	2 - Minor damage	Low	Low	Low	Medium	Medium
3 - Major health effect	3 - Local damage	Low	Low	Medium	Medium	High
4 - PTD or 1 fatality	4 - Major damage	Low	Medium	Medium	High	High
5 - Multiple fatalities	5 - Extensive damage	Medium	Medium	High	High	High

	HAZARD	RISK LEVEL	HAZARD	RISK LEVEL
Physical Hazards <input type="checkbox"/> None	<input checked="" type="checkbox"/> Heat	Low	<input checked="" type="checkbox"/> Holes/Pits	Low
	<input checked="" type="checkbox"/> Cold	Low	<input type="checkbox"/> Ionizing radiation	
	<input checked="" type="checkbox"/> Noise	Low	<input type="checkbox"/> Non-ionizing radiation	
	<input checked="" type="checkbox"/> Walking/Working Surfaces	Low	<input type="checkbox"/> Electricity	
	<input checked="" type="checkbox"/> Visible Dust	Medium	<input checked="" type="checkbox"/> Severe Weather	Low
	<input type="checkbox"/> LASER		<input checked="" type="checkbox"/> Poor lighting	Low
	<input type="checkbox"/> Other:		<input checked="" type="checkbox"/> Overhead Hazards	Medium
	<input type="checkbox"/> Other:		<input type="checkbox"/> Other:	

Environmental/Equipment Hazards <input type="checkbox"/> None	<input checked="" type="checkbox"/> Heavy machinery <input checked="" type="checkbox"/> Trenching/excavation <input type="checkbox"/> Docks – marine operations <input type="checkbox"/> Docks – loading <input type="checkbox"/> Diving operations <input type="checkbox"/> Drilling <input type="checkbox"/> Forklifts <input checked="" type="checkbox"/> Water operations work <input type="checkbox"/> Elevated heights <input checked="" type="checkbox"/> Overhead/Underground utilities <input type="checkbox"/> Confined spaces <input checked="" type="checkbox"/> Power Tools/Hand Tools	High Medium Low Medium Low	<input type="checkbox"/> Cranes/Hoists/Rigging <input type="checkbox"/> Ladders <input type="checkbox"/> Scaffolding <input type="checkbox"/> Man lifts <input type="checkbox"/> Welding <input type="checkbox"/> Gas cylinders <input type="checkbox"/> Roadway work <input type="checkbox"/> Railroad work <input type="checkbox"/> Energized equipment (LO/TO) <input type="checkbox"/> Pressurized equipment (LO/TO) <input type="checkbox"/> Drums and containers <input type="checkbox"/> Other:	
Biological Hazards <input type="checkbox"/> None	<input type="checkbox"/> Animal/human fluids or blood <input type="checkbox"/> Animal/human tissue(s) <input checked="" type="checkbox"/> Poisonous/irritating plants <input type="checkbox"/> Other:	Low	<input type="checkbox"/> Contaminated needles <input type="checkbox"/> Live bacterial cultures <input checked="" type="checkbox"/> Insects/rodents/snakes <input type="checkbox"/> Other:	Low
Ergonomic Hazards <input type="checkbox"/> None	<input checked="" type="checkbox"/> Repetitive motion <input checked="" type="checkbox"/> Awkward position <input type="checkbox"/> Heavy lifting <input type="checkbox"/> Frequent lifting <input type="checkbox"/> Other:	Low Low	<input type="checkbox"/> Limited movement <input type="checkbox"/> Forceful exertions <input checked="" type="checkbox"/> Vibration <input type="checkbox"/> Other: <input type="checkbox"/> Other:	Low
Personal Safety/Security <input type="checkbox"/> None	<input type="checkbox"/> Personal safety <input type="checkbox"/> Security issue <input checked="" type="checkbox"/> Project site in isolated area <input checked="" type="checkbox"/> Employees working alone <input type="checkbox"/> Other:	Low Low	<input checked="" type="checkbox"/> Employees working early/late <input type="checkbox"/> Potentially dangerous wildlife <input type="checkbox"/> Guard or stray dogs in area <input type="checkbox"/> No/limited cell phone service <input type="checkbox"/> Other:	Low
Driving Safety <input type="checkbox"/> None	<input checked="" type="checkbox"/> Driving early/late <input type="checkbox"/> Driving long trip <input type="checkbox"/> Driving Off-road <input type="checkbox"/> Other:	Low	<input type="checkbox"/> City Driving <input type="checkbox"/> Pulling trailer <input type="checkbox"/> Other:	

3.2 Job Safety Analysis

A Job Safety Analysis (JSA) must be completed for the task(s) being completed. Hazards identified above will be addressed in the JSA as well as control methods to be used to protect employees and property from hazards. JSAs for this project are included as **Appendix F**.

3.3 Chemical Hazards

Chemical	Hazards	TLV/PEL* 8-hr TWA	Ionization Potential	Estimate of quantity to be used or stored on site	Symptoms of Overexposure	Special Precautions
Lead	Noncombustible Solid	0.050 mg/m ³	NA	NA	Lassitude, insomnia; facial pallor; anorexia, low-weight, malnutrition; constipation, abdominal pain, colic, anemia; gingival lead line; tremor; paralysis of the wrist and ankles; encephalopathy; kidney disease; irritated eyes; hypotension	Lead is not only an inhalation hazard from airborne lead- containing dust, but also a significant ingestion hazard if proper personal hygiene and decontamination do not take place.
Petroleum Hydrocarbons	Flammable Liquid	350 mg/m ³	NA	NA	Irritation to the eyes, nose and throat; dizziness, drowsiness, headache, nausea; dry cracked skin; chemical pneumonitis (aspiration liquid)	A mixture of paraffin's that may contain a small amount of aromatic hydrocarbons.

*The TLV (Threshold Limit Value) from the American Conference of Governmental Industrial Hygienists is listed unless the PEL (Permissible Exposure Limit), designated by OSHA, is lower.

3.4 Hazard Communication (HazCom)

Prior to conducting the investigative activities, ARCADIS, USCG, and the subcontractor will conduct a tail gate safety meeting. ARCADIS, USCG, or the

drilling subcontractor personnel will not sample or handle any potential lead-based paint from the structures.

ARCADIS personnel and its subcontractors will not use or store any chemicals during the site activities. The USCG has vacated the site; thus, there are no chemicals stored at the site.

A copy of a Material Safety Data Sheets (MSDS) for lead is attached in Appendix G. In addition, the underground piping associated with the former underground storage tanks may contain residual heating oil (No. 2 fuel oil). Therefore, a copy of a MSDS for No. 2 fuel oil is included in Appendix G.

3.5 Air Monitoring

Air monitoring will be performed for each task per the table below. The abatement contractor will be responsible for conducting and documenting Real Time Air Monitoring during the lead-based paint abatement.

TASK 1 -- Archaeological Survey		
Is air monitoring required for this task? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		
Monitoring Equipment	Monitoring Frequency	Action Level
TASK 2 -- Lead in Soil Investigation		
Is air monitoring required for this task? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		
Monitoring Equipment	Monitoring Frequency	Action Level

TASK 3 -- Monitoring Well Installation/Groundwater Sampling		
Is air monitoring required for this task? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		
Monitoring Equipment	Monitoring Frequency	Action Level
TASK 4 -- Geological Survey		
Is air monitoring required for this task? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		
Monitoring Equipment	Monitoring Frequency	Action Level
TASK 5 -- UST Impact Delineation		
Is air monitoring required for this task? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		
Monitoring Equipment	Monitoring Frequency	Action Level
TASK 6 -- Investigation-Derived Waste (IDW) Management		
Is air monitoring required for this task? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		
Monitoring Equipment	Monitoring Frequency	Action Level

3.6 Client-Specific Health and Safety Requirements

Project workers will comply with the client's safety requirements at all times. The Project Manager is to be notified immediately if subcontractors or visitors are not following client-specific safety guidelines.

4. Decontamination Procedures

Level D decontamination protocol will be used with the following decontamination stations:

Level C Decontamination Steps		Level D Decontamination Steps	
1	Equipment Drop	1	Equipment Drop
2	Outer Garment, Boots, and Glove Wash and Rinse	2	Glove and Boot Wash and Rinse
3	Disposable Garment, Boots, and Glove Removal	3	Disposable Garment, Outer Boot, and Glove Removal
4	Cartridge Change (if necessary)	4	Field Wash
5	Remove Respiratory Protection		
6	Field Wash		

Place an X by all decontamination equipment that is required at the Site.

Decontamination Equipment Checklist			
x	Scrub Brushes	x	Garbage Bags
x	Waste Containers	x	Paper Towels
x	Soap	x	Isopropyl Alcohol
x	Plastic Tubs	x	Pump Spray Bottles
x	Plastic Drop Cloths	x	Pump Spray Bottles (water)

5. Emergency Procedures

In the event that an injury, over-exposure or spill has occurred, emergency response procedures will be implemented. The Site Safety Officer (SSO) will coordinate the entry and exit of response personnel during an emergency and make emergency contacts as necessary from the following list. After immediate notifications are made, the SSO will contact the Project Manager.

5.1 Emergency Contact Information

Emergency Contact	Phone Numbers
Local Police	911
Local Ambulance	911
Local Fire Department	911
Local Hospital – Mem. Med. Ctr. Of West Michigan	231.843.2591
National Response Center (all spills in reportable quantities)	800.424.8802
U.S. Coast Guard (spills to water)	804.441.3516
Associate Project Manager – Greg Zellmer	248.994.2283 (O) 248.789.8319 (C)
Client Contact – Greg Carpenter	216-902-6219 (O)
WORK CARE	800.455.6155

The Project Manager will make the following notifications:

Name	Phone Numbers
Environmental Division H&S Director – Mike Thomas	720.344.3835 (O) 720.308.2147 (C)
Health & Safety Manager/Specialist – Pat Vollertsen	720.344.3779 (O) 303.518.0622 (C)
Regional Health & Safety Manager – Lauren Edwards	317.231.6500 (O) 317.657.7234 (C)
Office Health & Safety Representative – Greg Zellmer	248.994.2283 (O) 248.789.8319 (C)

If emergency attention is not needed but professional medical attention is necessary, the employee will be taken to:

Medical Facility: Memorial Medical Center of West Michigan
Address: One Atkinson Drive
Ludington, MI 49431-1999
Phone Number: 231.843.2591

A map to the medical facility is included in **Appendix E**.

5.2 Emergency Equipment

	Emergency shower	x	First-aid kit
x	Emergency eyewash	x	Cell phone/radio
x	Fire extinguisher		Chemical spill kit
	Other:		Other:

All employees working on this project will be shown the location and proper use of all emergency equipment prior to beginning work on the project.

6. Department of Transportation (DOT) Dangerous Good Shipping Requirements

Hazardous materials and dangerous goods (re: Canadian regulatory term) are those materials that have one or more of the following characteristics: explosives, compressed and liquefied gases, flammable liquids and solids, oxidizing materials, and other substances that are poisonous, infectious, radioactive or corrosive. It is the handling, loading, packing or placing of hazardous materials (dangerous goods) in or from a container or vehicle at any facility for the purpose of transportation (including storing) in the course of transportation. This also includes the packing and transporting for air and ground shipment of laboratory analysis samples.

Regulations governing hazardous materials and dangerous goods exist to protect people, the environment, or property when these goods are being transported by road, rail, sea, or air. Given the increased emphasis of federal (i.e., Federal Aviation Administration and US Department of Transportation, and the Transportation of Dangerous Goods Act) attention to the transport of hazard material-containing goods, it is imperative that all shipments are packaged and transported such that they adhere to all federal requirements. ARCADIS has strict policies in place, whether shipping via ground or air, designed to meet the associated federal requirements. As such, only ARCADIS staff that have been trained in the proper methods to prepare and ship hazardous materials are authorized to do so. If you have not received training on the appropriate preparation and shipping protocols, you are to contact your supervisor or health and safety representative prior to packaging and/or shipping any material that is, or suspected to be, hazardous.

7. Project Team and Training

7.1 Personnel List

The associate project manager is responsible for safety at the project site and for ensuring that all site workers have reviewed the HASP and understand the hazards. The associate project manager must also ensure that the necessary PPE is procured and provided to site workers. The task manager assists the associate project manager in implementing safety measures at the site, and conveys any safety concerns to the associate project manager.

The SSO officer is responsible for implementing the HASP at the project site. If any site personnel or visitors do not comply with the HASP, the SSO will cease all work

until personnel/visitors comply. The SSO will contact the APM/TM to inform them of any personnel not complying with the HASP.

Associate Project Manager: Greg Zellmer
Task Manager: Troy Sclafani
Site Safety Officer: Paul Lenaker
Site Workers: Paul Lenaker

7.2 Training Requirements

All personnel working at the site must have the necessary training based on the hazards present. The following training is required for all site workers:

Training Required:	<input checked="" type="checkbox"/> 40-hour HAZWOPER <input type="checkbox"/> 24-hour HAZWOPER <input type="checkbox"/> HAZWOPER site supervisor <input type="checkbox"/> OSHA 30-hour Construction <input type="checkbox"/> OSHA 10-hour Construction <input checked="" type="checkbox"/> PPE <input checked="" type="checkbox"/> Respiratory protection <input type="checkbox"/> Chemical hygiene <input checked="" type="checkbox"/> Hazard communication <input type="checkbox"/> Hazardous waste <input checked="" type="checkbox"/> First-aid/CPR/Bloodborne pathogens <input checked="" type="checkbox"/> DOT/IATA hazmat transportation <input type="checkbox"/> Diving <input type="checkbox"/> Boating safety	<input type="checkbox"/> Confined space <input type="checkbox"/> Lockout/tagout <input type="checkbox"/> Electricity <input checked="" type="checkbox"/> Fire extinguishers <input type="checkbox"/> Fall protection <input type="checkbox"/> Noise exposure <input type="checkbox"/> Forklifts <input type="checkbox"/> Asbestos <input checked="" type="checkbox"/> Lead <input type="checkbox"/> Cadmium <input type="checkbox"/> Radiation safety <input type="checkbox"/> Client specific <input type="checkbox"/> Other:
<input type="checkbox"/> None		
Medical Screening	<input checked="" type="checkbox"/> Medical Surveillance Exam (HAZWOPER) <input type="checkbox"/> Client required drug and/or alcohol testing	<input type="checkbox"/> Blood and/or urine screening for other hazardous substances

All 40-hour HAZWOPER trained personnel who are working at HAZWOPER project sites are required to participate in the ARCADIS medical surveillance program as outlined in the Corporate Health and Safety Manual.

7.3 Subcontractors

A copy of this HASP is to be provided to all subcontractors prior to the start of work so that the subcontractor is informed of the hazards at the site. While the ARCADIS HASP will be the minimum H&S requirements for the work completed by ARCADIS

and its subcontractors, each subcontractor, in coordination with ARCADIS H&S personnel, is expected to perform its operations in accordance with its own HASP, policies and procedures unique to the subcontractor's work to ensure that hazards associated with the performance of the work activities are properly controlled. Copies of any required safety documentation for a subcontractor's work activities will be provided to ARCADIS for review prior to the start of on-site activities.

In the event that the subcontractor's procedures/requirements conflict with requirements specified in this HASP, the more stringent guidance will be adopted after discussion and agreement between the subcontractor and ARCADIS project H&S personnel. Hazards not listed in this HASP, but known to the subcontractor or known to be associated with the subcontractor's services, must be identified and addressed to the ARCADIS Project or Task Manager and SSO prior to beginning work operations.

Health and Safety Plan

United States Coast Guard
Old Station Ludington

8. Project Personnel HASP Certification

8.1 ARCADIS Personnel Signature Page

I certify that I have read, understand, and will abide by the safety requirements outlined in this HASP.

Printed Name	Signature	Date

8.2 Subcontractor Acknowledgement: Receipt of HASP

ARCADIS claims no responsibility for the use of this HASP by others although subcontractors working at the Site may use this HASP as a guidance document. In any event, ARCADIS does not guarantee the health and/or safety of any person entering this Site. Strict adherence to the health and safety guidelines provided herein will reduce, but not eliminate, the potential for injury at this Site. To this end, health and safety becomes the inherent responsibility of personnel working at the Site.

Printed Name	Company	Signature	Date

8.3 Visitor Acknowledgement and Acceptance of HASP

By signing below, I waive, release and discharge the Owner of the Site and ARCADIS and their employees from any future claims for bodily and personal injuries which may result from my presence at, entering, or leaving the Site and in any way arising from or related to any and all known and unknown conditions on the Site.

Name	Company	Reason for Visit	Date/Time On Site	Date/Time Off Site

ARAD5

Appendix A

HASP Addendum Pages

Addendum Page

This form should be used to document any changes required to this HASP. These changes may be a result of changes to the scope of services, changes in field conditions, new hazards identified on the Site, higher or lower hazards than anticipated, etc. Please complete this form prior to the next work day once the changes have been identified. Review the modifications with all Site staff, including subcontractors, during the daily tailgate briefing, and complete the tailgate briefing form as required. Attach a copy of the addendum to all copies of the HASP including the Site copy, and log in the Addendum Log in Section 1.0.

Addendum Number: _____ Project Number: _____
Date of Changed Conditions: _____ Date of Addendum: _____

Description of Change that Results in Modifications to HASP:

Hazard Analysis for Change in Work:

HAZARD		Level of Risk:	
Source of Hazard			
Admin. & Eng. Controls		PPE:	
HAZARD		Level of Risk:	
Source of Hazard			
Admin. & Eng. Controls		PPE:	

Signed: _____
Project Manager

Signed: _____
Site Safety Officer

Signed: _____
H&S Plan Writer

Signed: _____
H&S Plan Reviewer

ARCADIS

Appendix B

PPE Checklist

Description (Specify Material or Type in Box)	Level Of Protection R = Required O = Optional	
	D	C
Body		
Coveralls	R (Tyvek)	
Chemical Protective Suit		
Splash Apron		
Rain Suit	O	
Traffic Safety Vest (reflective)	R	
Head		
Hard Hat (if does not create other hazard)	R	
Head Warmer (depends on temperature and weather)	O	
Eyes & Face		
Safety Glasses (incorporate sun protection as necessary)	R	
Goggles (based on hazard)	O	
Splash Guard (based on hazard)		
Ears		
Ear Plugs	R	
Ear Muffs	O	
Hands and Arms		
Outer Chemical Resistant Gloves	O	
Inner Chemical Resistant Gloves (i.e. Nitrile)	R	
Insulated Gloves	O	
Work Gloves	O	
Foot		
Safety Boots (steel toe and shank)	R	
Rubber, Chemical Resistant Boots		
Rubber Boots	R (near water)	
Disposable Boot Covers	R	
Respiratory Protection (indicate cartridge type where applicable)		
Dust Protection		
1/2 Mask APR		
Full Face APR		
Full Face Canister APR with HEPA cartridges		R
Powered APR		
Other Supplies		
First Aid Kit	R	
Fire Extinguisher	R	
Mobile Phone	R	
Traffic Cones	O	
Walkie Talkies	O	
Water or Other Fluid Replenishment	R	
Eye Wash Station	O	
Eye Wash Bottle	R	
Wash and Dry Towelettes	R	
Sunscreen (SPF 15 or higher)	R	
Insect Repellent	R	

AR005

Appendix C

Tailgate Briefing Sign-in Log

[illegible]

ARCADIS

Appendix D

Real Time Air Monitoring Log

APC-15

Real Time Air Monitoring Data Collection Form

Document all air monitoring conducted on the Site below based on Section E of the HASP. Keep this form with the project files.

Site Name: _____ Date: _____

Instrument: _____ Model: _____ Serial #: _____

Calibration Method: (material used, settings, etc.)	
Calibration Results:	
Calibrated By:	

Activity Being Monitored	Compounds Monitored	Time	Reading	Action Required? Y/N

Describe Any Actions Taken as a Result of this Air Monitoring and Why:

ASQARS

Appendix E

Map to the Hospital



ARCADIS

Appendix F

Job Safety Analysis



JOB SAFETY ANALYSIS

SECTION 1

JSA Type:	Environmental Operations
JSA No:	JSA000704
Date:	3/14/2008
Work Type:	Environmental - Ground Water Sampling
Work Activity:	Ground Water Sampling
Project No.:	OH0002940011 - GM/MORaine OMM ACTIVITIES 2007 (GM/MORaine OMM ACTIVITIES 2007)

SECTION 2

Development Team	Position/Title	PC	Reviewed By	Position/Title	Date
Coppola, Mija A.	H&S	<input checked="" type="checkbox"/>	Coppola, Mija A.	H&S	3/14/2008

SECTION 3

Job Steps	Potential Hazard(s)	Critical Action(s)	SOP Reference
Open wells to equilibrate and gauge wells.	When squatting down, personnel can be difficult to see by vehicular traffic. Pinchpoints on well vault can pinch fingers. Exposure to COCs in groundwater. Pressure can build up inside wells causing well caps to project into the air.	Wear Class II traffic vest if wells are located proximal to vehicular traffic. Use tall cones and the buddy system if practicable. Use correct tools to open well vault/cap. Wear proper PPE including safety boots, knee pads and safety glasses. Wear leather gloves when removing well vault lids, and chemical protective gloves while gauging. Keep head away from well cap when opening.	
Stage at pre-determined sampling location and set up work zone and sampling equipment	Slips, trips and falls can occur from equipment lying on the ground and uneven ground surfaces.	Set-up cones and establish work area. Position vehicle so that field crew is protected from site traffic. Unload as close to work area as safely possible; use proper lifting and reaching techniques and body positioning; don't carry more than you can handle, and get help moving heavy or awkward objects.	
Well purging	Electrical shock can occur when connecting/disconnecting pump from the battery. Lacerations to hand/fingers can occur when cutting tubing. Muscle strain can occur when lifting equipment, pinch point between tubing and well casing while lowering pump or bailers. Exposure to	Wear protective gloves and lower pump/bailer slowly. Cut tubing with tube cutting device (do not use pocket knife). Take stretch breaks as needed. Pour water slowly into buckets to minimize splashing. Use proper lifting techniques when	

	COCs from splashing of water when pouring into 5 gallon bucket.	moving equipment. Use two people if necessary; wear safety glasses and gloves.
Moving purge buckets, and emptying water into drums.	Splashing can cause exposure to COCs in groundwater. Back/muscle strain from lifting and carrying 5 gallon buckets of water.	To minimize splashing and to keep the load at a reasonable weight, do not overfill buckets. Use proper lifting techniques. If buckets need to be transported to the purge storage containers, cover the buckets with lids to minimize spillage and move using a cart, dolly, or by putting in the back of truck.
Collect groundwater sample	Cuts to hand and potential contact with COCs. Back strain from lifting full coolers. Exposure to sample preservatives.	Make sure glass sample containers are not cracked or broken. Ensure proper PPE is used to prevent dermal exposure. When lifting, use proper lifting techniques. Get help when moving heavy or awkward loads.
Load equipment and samples back into vehicle.	Lifting hazards and back strain.	Use proper lifting techniques. Request assistance when lifting heavy equipment.

SECTION 4

Personal Protective Equipment (PPE):

Level D

Orange Traffic Safety Vest

Protective Gloves - Nitrile or Latex



JOB SAFETY ANALYSIS

SECTION 1

JSA Type:	Soil Sampling
JSA No:	JSA001378
Date:	3/28/2008
Work Type:	Environmental - Surface Soil Sampling
Work Activity:	Surficial and shallow soil sampling with shovel
Project No.:	KC0015580001 - UPRR/DILLER NE - ROELFS PROPERTY (UPRR/DILLER NE - ROELFS PROPERTY)

SECTION 2

Development Team	Position/Title	PC	Reviewed By	Position/Title	Date
Lloyd, Tina	HASP Writer	<input checked="" type="checkbox"/>	Lloyd, Tina	HASP Writer	4/22/2008
			Thomas, Michael A.	HASP Reviewer	3/31/2008

SECTION 3

Job Steps	Potential Hazard(s)	Critical Action(s)	SOP Reference
Load equipment and supplies into vehicle.	Lifting hazards and back strain. Pinch points. Breaking glass in coolers. Spilling decontamination chemicals.	Use proper lifting technique. Request assistance when lifting heavy equipment. Use dolly to transport coolers, if necessary. Load coolers and decontamination materials so they will not shift during transport.	
Mobilize. Drive to the site.	Vehicle accident. Loss of equipment/supplies from moving vehicle.	Follow safe driving procedures (inspect vehicle prior to driving, safe following distances, headlights, safety belts, etc.). Do not use cell phone when driving. Properly secure all equipment and supplies before operating vehicle.	
Property Access	Vehicle, pedestrian, and RR traffic.	Be aware of vehicle and RR traffic on-site and surroundings. Follow site traffic regulations (speed limit, right-of-way). Be aware of pedestrians.	
Working Outdoors	Temperature-related illnesses (heat-stress, cold-stress). Weather. Biological hazards (wasps, spiders, animals, vegetation, etc.).	Drink plenty of fluids, take breaks as needed to avoid overheating, frostbite, etc., dress appropriately for weather conditions. Use sunscreen as appropriate, monitor changes in weather, postpone work if lightning is observed or expected. Wasps, spiders, bee, etc. may be present.	
Tailgate Safety Meetings/TRACK (SPSA)	Injury or property damage due to unknown or known hazards present.	Discuss work to be performed and associated hazards. Open communication among team members. Have all team members sign safety meeting form and JSA. SPSA (Assess, Analyze, and Act) prior to starting new work. Discuss any new or unknown hazard identified from SPSA.	
Access to soil sampling area (agricultural field)	Traffic hazards, pinch points, tripping hazards.	If soil near a traffic area wear safety vest, place cones to delineate work area. When possible, position vehicle to protect from oncoming traffic. Wear work gloves and safety glasses when loosening soil.	
Collecting soil samples	Exposure to site constituents of concern. Back strain. Slips, trips, falls.	Wear sampling/ nitrile gloves. Decontaminate non-disposable sampling equipment between each sampling run. Keep samples stored in proper containers, on ice, and away from work area. Be cautious of footing on uneven ground.	
Packaging samples to be picked up or shipped to the lab.	Bottle breakage, back strain, sample cross contamination.	Pack coolers to minimize sample jar movement inside. Use paper, cardboard or foam. Use proper lifting techniques.	
Demobilize. Driving back from site.	Slips, trips, and falls. Lifting hazards and back strain. Vehicle accident. Loss of equipment /supplies from moving vehicle.	Leave site clean of refuse and debris. Use proper lifting technique. Request assistance when lifting heavy equipment. Use dolly to transport equipment, if needed. Properly secure all equipment and supplies before before operating vehicle. Follow safe driving procedures (safe	

following distances, headlights, safety belts, etc..)
Do not use cell phone when driving.

SECTION 4

Personal Protective Equipment (PPE):

Orange Traffic Safety Vest

Protective Gloves - nitrile for sampling, leather for accessing sampling area

Safety Glasses

Safety Shoes

Required and/or Recommended Equipment and Supplies:

JSA001378 - Closed - Current - 08/06/2008 12:08 PM EST



JOB SAFETY ANALYSIS

SECTION 1	
JSA Type:	Environmental Operations
JSA No:	JSA001511
Date:	5/21/2008
Work Type:	Environmental - Monitoring Well/Piezometer Installation
Work Activity:	Oversight- Monitor Well Installation using Hollow Stem Auger or Sonic Drilling Method (includes soil sampling activities during installation)
Project No.:	B00380550000 - FORMER ABC SITE (FORMER ABC SITE)

SECTION 2					
Development Team	Position/Title	PC	Reviewed By	Position/Title	Date
Stahl, Bridget C.	Staff Scientist		Bullock, David M.	Southeast Regional Health and Safety Specialist	5/21/2008
			Thalman, Katherine L.	Office Health and Safety Coordinator	5/21/2008

SECTION 3			
Job Steps	Potential Hazard(s)	Critical Action(s)	SOP Reference
Load required PPE, sampling equipment, and supplies into vehicle.	Lifting hazards, back strain, appropriate PPE not on site.	Review HASP/ JSA for proper PPE; Employ safe lifting techniques such as bending from the knees (not at the waist) and reducing twisting/side to side motion. Request assistance when lifting heavy objects (> 50 lbs)	
Driving	Vehicle traffic/ Train traffic on site, damage to vehicle from decommissioning debris (flat tire, etc.), construction, heavy machinery, personnel on site.	Be aware of surroundings, perform TRACK, obtain proper passes, stickers, identification, and track protection (if required) to work on site. Stop and look in all directions before crossing tracks. Follow all client specific health and safety regulations/procedures.	See Driving JSA for mobilization/demobilization from site.
Clear drilling locations.	Traffic hazards. Overhead and underground utility installations. Product releases. Property damage	Initiate one call system for identification of utilities and get a list of the utilities contacted prior to drilling activities. If necessary coordinate private line locator for private property. Inspect area for obvious signs of utilities. Reference Utility Clearance Review Form. Review proposed locations against available construction drawings for utilities, tanks, product lines, etc. Clearly mark proposed borehole locations. Clear pathways for moving equipment into and out of work area. Review HASP and permit conditions.	ARC HSFS019 (Utility Locate). See Appendix E.
Set up of Drill Rig at Well Location	Vehicle accident during rig movement. Damage caused by rig while accessing set-up location. Contact with overhead installations. Soft terrain, (rig sinking). Unwanted rig movement. Slips, trips, and falls.	Verify clear pathway to sampling location and clearance for raising mast. Provide as-needed hand signals and guidance to driver to place rig. Visually inspect rig (fire extinguisher on board, no oil or other fluid leaks, cabling/tooling and associated equipment in good condition, pressurized hoses secured with whip-checks or adequate substitute, jacks in good condition). Implement exclusion zone set-up. Set up work stations with clear walking paths to and from equipment. Never allow a rig to move with the mast upright!	
Clear upper five feet of drilling location using a hand auger.	Back strain, Exposure to chemical hazards, Contact with underground utilities, Repetitive motion injury, forceful exertions.	Use proper lifting techniques (bend at knees, not waist, minimize twisting) and tools. Share augering duties between field personnel to reduce repetitive motions. take breaks as needed. Complete the Underground	

		Utility Checklist.	
Commence soil sample collection using Drill Rig	Cross-contamination from previous boring. Back strain. Heat or cold stress. Eye injury. Exposure to chemical hazards. Excessive noise exposure. Contact with underground utilities. Slips, trips and falls, cuts, pinch points (split-spoons), Equipment failure.	Decontaminate sampling equipment after collecting a sample and decontaminate drilling equipment after each borehole using decontamination procedure annotated on Decontamination JSA. Use two people or more to lift heavy or awkward objects, minimize bending and twisting at the waist when lifting. Use PPE and air monitoring in accordance with HASP (especially note hearing protection). Monitor drilling progress, make notations and observations in the field log book. Keep work area clear of tripping or slipping hazards. Perform periodic visual inspections of drill rig and equipment. Use Nitrile gloves when handling soil and work gloves when handling rig equipment such as hollow stem augers, split-spoons, etc...If cutting sleeves for lithology, cut away from the body.	See Decontamination of Field Equipment JSA for proper decontamination procedures.
Collect samples in accordance with sampling plan.	Cross-contamination. Improper labeling or storage. Exposure to site contaminants. Injuries related to cutting acetate liner with knife.	Decontaminate sampling equipment between each sampling run. Label samples in accordance with the sampling plan. Store samples in proper containers, at correct temperature, and away from work area. Do not overtighten sample bottle caps. Perform air monitoring and wear proper PPE as given in the HASP. Use extreme caution (wear gloves, cut slowly keeping fingers away from the blade, cut away from the body, replace dull blades to prevent snagging or need for excessive force) when cutting acetate liner.	
Well Construction	Silicosis from mixing Portland Cement and installing sand packs, injury from cutting pipe, back sprain/strains from handling sand bags and cement bags, mixing grout, and well pad completions, eye irritation from dust when mixing cement	Stay upwind when mixing and pouring cement, wear dust mask and safety glasses to avoid eye and skin irritation, use appropriate pipe cutter for monitor well height adjustment, utilize proper lifting techniques, use two man lifts for any bagged material >50lbs, don't overload/shovel, take your time.	
Store cuttings, properly in accordance with site-specific requirements.	Exposure to public. Exposure to contaminants. Traffic hazard or obstruction/inconvenience to site operation. Improper storage or disposal.	Have proper containment and labeling available on-site. Place materials in isolated location away from traffic and other site functions. Coordinate proper off-site disposal (where applicable). Use equipment such as pumps, drums, dollies, etc.) to transport water and/or cuttings. Wear PPE in accordance with HASP while conducting staging or disposal activities.	
Backfill borehole (as required in scope of work)	If backfill not performed immediately after drilling, slip/trip/fall hazards may become associated with the open hole. Back strain, eye injury from splashing or release of pressurized grout (if used) Unauthorized backfilling causes extra work.	Backfilling borehole should be done in accordance with the scope of work. Verify borehole backfill requirements (grouting vs. bentonite chips). If using grout, mix grout to specification and completely fill the hole.	
Package and deliver/ship samples to lab.	Bottle breakage. Cuts or acid burns. Back strain.	Do not overtighten bottle caps. Handle and pack bottle carefully (bubble wrap bags are helpful). Avoid contact with tape cutter, or cut away from the hand and body if using knife. Minimize bending and twisting while lifting; use two or more people as needed for heavy/awkward sample coolers. Use proper lifting techniques.	
Site Clean-up	Lifting hazards, back strain, fatigue	Employ safe lifting techniques such as bending from the knees (not at the waist), and reducing twisting/side to side motion. Request assistance when lifting heavy objects (>50 lbs). Notify site personnel of departure and location of any cuttings/purge water left on-site.	

SECTION 4
Personal Protective Equipment (PPE):
Hard Hat
Level D
Protective Gloves - Nitrile, Leather
Safety Glasses
Safety Shoes
<u>Required and/or Recommended Equipment and Supplies:</u>
ANSI Level II Safety Vests
Dust mask/respirator as needed
hearing protection as needed
sunscreen
Insect repellent
Rain gear/ Inclement weather clothing
First Aid kit
Portable eyewash station
2-way radio/cell phones
Traffic cones as necessary

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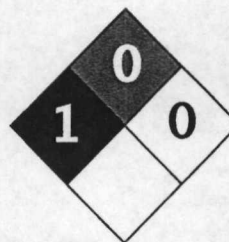
Appendix G

Material Safety Data Sheets



Science

Chemicals & Laboratory Equipment



Health	1
Fire	0
Reactivity	
Personal Protection	E

Material Safety Data Sheet Lead MSDS

Section 1: Chemical Product and Company Identification

Product Name: Lead

Catalog Codes: SLL1291, SLL1669, SLL1081, SLL1459, SLL1834

CAS#: 7439-92-1

RTECS: OF7525000

TSCA: TSCA 8(b) inventory: Lead

CI#: Not available.

Synonym: Lead Metal, granular; Lead Metal, foil; Lead Metal, sheet; Lead Metal, shot

Chemical Name: Lead

Chemical Formula: Pb

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Lead	7439-92-1	100

Toxicological Data on Ingredients: Lead LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:

Slightly hazardous in case of skin contact (permeator).

CARCINOGENIC EFFECTS: Classified A3 (Proven for animal.) by ACGIH, 2B (Possible for human.) by IARC.

MUTAGENIC EFFECTS: Not available.

TERATOGENIC EFFECTS: Not available.

DEVELOPMENTAL TOXICITY: Not available.

The substance may be toxic to blood, kidneys, central nervous system (CNS).

Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation occurs.

Skin Contact: Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops.

Serious Skin Contact: Not available.

Inhalation:

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:

Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Explosion Limits: Not available.

Products of Combustion: Some metallic oxides.

Fire Hazards in Presence of Various Substances: Non-flammable in presence of open flames and sparks, of shocks, of heat.

Explosion Hazards in Presence of Various Substances:

Risks of explosion of the product in presence of mechanical impact: Not available.

Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:

SMALL FIRE: Use DRY chemical powder.

LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: When heated to decomposition it emits highly toxic fumes of lead.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:

Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:

Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system. Be careful that the product is not

present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:

Keep locked up.. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe dust. Wear suitable protective clothing. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:

Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:

TWA: 0.05 (mg/m³) from ACGIH (TLV) [United States]

TWA: 0.05 (mg/m³) from OSHA (PEL) [United States]

TWA: 0.03 (mg/m³) from NIOSH [United States]

TWA: 0.05 (mg/m³) [Canada] Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Metal solid.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 207.21 g/mole

Color: Bluish-white. Silvery. Gray

pH (1% soln/water): Not applicable.

Boiling Point: 1740°C (3164°F)

Melting Point: 327.43°C (621.4°F)

Critical Temperature: Not available.

Specific Gravity: 11.3 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

r/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility: Insoluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, excess heat

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:

Can react vigorously with oxidizing materials.

Incompatible with sodium carbide, chlorine trifluoride, trioxane + hydrogen peroxide, ammonium nitrate, sodium azide, disodium acetylide, sodium acetylide, hot concentrated nitric acid, hot concentrated hydrochloric acid, hot concentrated sulfuric acid, zirconium.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Inhalation. Ingestion.

Toxicity to Animals:

LD50: Not available.

LC50: Not available.

Chronic Effects on Humans:

CARCINOGENIC EFFECTS: Classified A3 (Proven for animal.) by ACGIH, 2B (Possible for human.) by IARC.
May cause damage to the following organs: blood, kidneys, central nervous system (CNS).

Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans:

Acute Potential:

Skin:

Lead metal granules or dust: May cause skin irritation by mechanical action.

Lead metal foil, shot or sheets: Not likely to cause skin irritation

Lead metal granules or dust: Can irritate eyes by mechanical action.

Lead metal foil, shot or sheets: No hazard. Will not cause eye irritation.

Inhalation:

In an industrial setting, exposure to lead mainly occurs from inhalation of dust or fumes.

Lead dust or fumes: Can irritate the upper respiratory tract (nose, throat) as well as the bronchi and lungs by mechanical action. Lead dust can be absorbed through the respiratory system. However, inhaled lead does not accumulate in the lungs. All of an inhaled dose is eventually absorbed or transferred to the gastrointestinal tract. Inhalation effects of exposure to fumes or dust of inorganic lead may not develop quickly. Symptoms may include metallic taste, chest pain, decreased physical fitness, fatigue, sleep disturbance, headache, irritability, reduces memory, mood and personality changes, aching bones and muscles, constipation, abdominal pains, decreasing appetite. Inhalation of large amounts may lead to ataxia, delirium, convulsions/seizures, coma, and death.

Lead metal foil, shot, or sheets: Not an inhalation hazard unless metal is heated. If metal is heated, fumes will be released. Inhalation of these fumes may cause "fume metal fever", which is characterized by flu-like symptoms. Symptoms may include metallic taste, fever, nausea, vomiting, chills, cough, weakness, chest pain, generalized muscle pain/aches, and increased white blood cell count.

Ingestion:

Lead metal granules or dust: The symptoms of lead poisoning include abdominal pain or cramps (lead cholic), spasms, nausea, vomiting, headache, muscle weakness, hallucinations, distorted perceptions, "lead line" on the gums, metallic taste, loss of appetite, insomnia, dizziness and other symptoms similar to that of inhalation. Acute poisoning may result in high lead levels in the blood and urine, shock, coma and death in extreme cases.

Lead metal foil, shot or sheets: Not an ingestion hazard for usual industrial handling.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations:

California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer, birth defects or other reproductive harm, which would require a warning under the statute: Lead

California prop. 65: This product contains the following ingredients for which the State of California has found to cause reproductive harm (female) which would require a warning under the statute: Lead

California prop. 65: This product contains the following ingredients for which the State of California has found to

cause reproductive harm (male) which would require a warning under the statute: Lead
California prop. 65 (no significant risk level): Lead: 0.0005 mg/day (value)
California prop. 65: This product contains the following ingredients for which the State of California has found to
cause birth defects which would require a warning under the statute: Lead
California prop. 65: This product contains the following ingredients for which the State of California has found to
cause cancer which would require a warning under the statute: Lead
Connecticut hazardous material survey.: Lead
Illinois toxic substances disclosure to employee act: Lead
Illinois chemical safety act: Lead
New York release reporting list: Lead
Rhode Island RTK hazardous substances: Lead
Pennsylvania RTK: Lead

Other Regulations:

OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).
EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC):

R20/22- Harmful by inhalation and if
swallowed.
R33- Danger of cumulative effects.
R61- May cause harm to the unborn
child.
R62- Possible risk of impaired fertility.
S36/37- Wear suitable protective clothing and
gloves.
S44- If you feel unwell, seek medical advice
(read the label when possible).
Avoid exposure - obtain special
instructions before use.

HMIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:

Gloves.
Lab coat.
Dust respirator. Be sure to use an
approved/certified respirator or
equivalent. Wear appropriate respirator
when ventilation is inadequate.

Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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Last Updated: 10/10/2005 08:21 PM

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Issue Date: 2006-06

Section 1 - Chemical Product and Company Identification

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Material Name: Fuel Oil No. 2 **CAS Number:** 68476-30-2
Chemical Formula: Un; Va
Structural Chemical Formula: Unspecified; Variable
EINECS Number: 270-671-4
ACX Number: X1010102-3
Synonyms: #2 HOME HEATING OILS; API NO. 2 FUEL OIL; FUEL OIL NO. 2; FUEL OIL, NO. 2; GAS OIL; HOME HEATING OIL NO.2; NUMBER 2 BURNER FUEL; NUMBER 2 FUEL OIL
Derivation: Residue from distillation (straight run or cracked) of crude oil.
General Use: Used as a fuel in atomizing burners for domestic and industrial heating, in engines of heavy units (ships, trucks, trains), as a source of synthesis gas, in drilling muds, and for mosquito control (coats breeding waters).

Section 2 - Composition / Information on Ingredients

Name	CAS	%
Fuel oil no. 2	68476-30-2	ca 100% vol
(complex mixture (< 95%) of paraffinic, olefinic, naphthenic, and aromatic hydrocarbons)		
Trace Impurities: water and sediment (< 0.05% vol), carbon residue (< 0.35%), ash (< 0.01% wt), sulfur (< 0.7% wt) and benzene (< 100 ppm).		

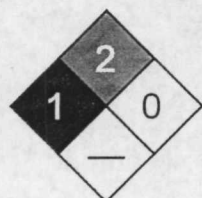
OSHA PEL

NIOSH REL

ACGIH TLV

TWA: 100 mg/m³; skin.

Section 3 - Hazards Identification



Fire Diamond

Flammability
Toxicity
Body Contact
Reactivity
Chronic

ChemWatch Hazard Ratings				
0 Min	1 Low	2 Moderate	3 High	4 Extreme

HMIS	
①	
②	Flammability
③	Reactivity

ANSI Signal Word

Warning!

Flammable

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Amber to brown, slightly viscous liquid; petroleum odor. Irritating to skin/respiratory tract. Other Acute Effects: aspiration hazard, chemical pneumonitis, respiratory failure, vomiting, diarrhea, CNS depression, increased respiration, rapid heart beat, cyanosis. Flammable.

Potential Health Effects

Target Organs: Skin, CNS, cardiovascular system (CVS), respiratory system, mucous membranes

Primary Entry Routes: Inhalation, ingestion

Acute Effects

Inhalation: Respiratory tract irritation, headache, dizziness, euphoria, nausea, increased respiration rate, tachycardia (excessively rapid heart beat), cyanosis, stupor, convulsions, and unconsciousness can result from inhalation of fuel oil no. 2 mist.

Eye: Contact may result in irritation.

Skin: Contact may cause irritation.

Ingestion: Gastrointestinal irritation, vomiting, diarrhea, and in severe cases, CNS depression, progressing to coma and death, can result. Since intestinal absorption of longer chain hydrocarbons is minimal, aspiration into lungs following ingestion is a more significant exposure route; it may result in transient CNS depression, hemorrhaging and pulmonary edema, progressing to renal (kidney) involvement, chemical pneumonitis, and respiratory failure.

Carcinogenicity: NTP - Not listed; IARC - Group 3, Not classifiable as to carcinogenicity to humans; OSHA - Not listed; NIOSH - Not listed; ACGIH - Not listed; EPA - Not listed; MAK - Not listed.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Chronic Effects: Prolonged and repeated skin contact can cause dermatitis, irritate the hair follicles and may block the (oil) sebaceous glands, producing a rash of acne pimples, usually on the arms and legs. Repeated exposures producing CNS effects may lead to permanent nervous system damage.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 minutes. Consult a physician or ophthalmologist if pain and/or irritation develop.

See
DOT
ERG

Skin Contact: Quickly remove contaminated clothing. Rinse with flooding amounts of water followed by washing the exposed area with soap and water. For reddened or blistered skin, consult a physician.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. *Do not* induce vomiting unless the poison control center advises otherwise.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Gastric lavage for treatment of ingestion is contraindicated due to aspiration hazard. Administer charcoal slurry cathartic (30 g/240 mL diluent). In cases of severe aspiration pneumonitis, consider monitoring arterial blood gases and obtain chest x-ray.

Section 5 - Fire-Fighting Measures

Flash Point: 136 °F (57.78 °C), Closed Cup

Autoignition Temperature: 494 °F (257 °C)

LEL: 0.6% v/v

UEL: 7.5% v/v

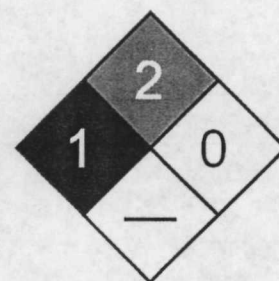
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DOT
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Flammability Classification: OSHA Class II Combustible Liquid.

Extinguishing Media: Use dry chemical, carbon dioxide, foam, water fog or spray. Water may be ineffective in putting out a fire involving fuel oil no. 2, and a solid water stream may spread the flames; however, a water spray may be used to cool fire-exposed containers, and flush spills away from ignition sources.

General Fire Hazards/Hazardous Combustion Products: Heating fuel oil no. 2 to decomposition can produce thick acrid smoke and irritating fumes. Can form explosive mixtures in air. In still air, the heavier-than-air vapors of fuel oil no. 2 may travel along low-lying surfaces to distant sources of ignition and flash back to the material source. Containers may explode in heat of fire.

Fire-Fighting Instructions: If tank, rail car or tank truck is involved in fire isolate for 1/2 mile (800 m). *Do not* release runoff from fire control methods to sewers or waterways. Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.



Fire Diamond

Section 6 - Accidental Release Measures

Spill/Leak Procedures: Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. *Do not* touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Isolate area for at least 80-160 ft (25-50 m) in all directions. Water spray or fire fighting foam may suppress vapor, but may not prevent ignition in closed spaces. Use natural barriers or oil spill control booms to confine oil slicks on surface water.

See
DOT
ERG

Small Spills: Absorb fuel oil no. 2 with vermiculite, earth, sand or similar material.

Large Spills: For large spills, consider downwind evacuation of at least 1000 ft (300 m). Dike far ahead of liquid spill for later disposal. *Do not* release into sewers or waterways. Ground all equipment. Spills can be absorbed with materials such as peat, activated carbon, polyurethane foam, or straw. Sinking agents, gelling agents, dispersants, and mechanical systems can also be used to treat oil spills. Use clean non-sparking tools to collect absorbed material.

Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Avoid vapor or mist inhalation, and skin and eye contact. Use only with ventilation sufficient to reduce airborne concentrations as low as possible. Wear protective gloves (or use barrier cream) and clothing (see Sec. 8). Keep away from heat and ignition sources. Ground and bond all containers during transfers to prevent static sparks. Use non-sparking tools to open and close containers. .

Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Recommended Storage Methods: Store in tightly closed container in cool, well-ventilated area, away from heat, ignition sources and incompatibles (See Sec. 10). Periodically inspect stored materials. Equip drums with self-closing valves, pressure vacuum bungs, and flame arrestors.

Regulatory Requirements: Follow applicable OSHA regulations. Also 29 CFR 1910.106 for a Class II Combustible Liquid.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations. Provide general or local exhaust ventilation systems to maintain airborne concentrations as low as possible. Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.

Administrative Controls: Enclose operations and/or provide local exhaust ventilation at the site of chemical release designed for flammable vapors/mists. Where possible, transfer fuel oil no. 2 from drums or other storage containers to process containers. Minimize sources of ignition in surrounding low-lying areas.

Personal Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets of Viton or nitrile rubber, if possible, or alternatively, polyvinyl chloride, chlorinated polyethylene or neoprene to prevent skin contact. Butyl rubber may degrade after contact and is not recommended. Wear protective eyeglasses per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), use an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Other: Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment. Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Section 9 - Physical and Chemical Properties

Appearance/General Info: Amber to brown, slightly viscous; petroleum odor.

Physical State: Liquid

Odor Threshold: Medium odor threshold 0.082 ppm

Formula Weight: N/A

Specific Gravity (H₂O=1, at 4 °C): 0.8654 at 59 °F (15 °C)

Boiling Point: 450 °F (232 °C)

Freezing/Melting Point: -50.8 °F (-46 °C)

Viscosity: 268 centistoke at 100 °F (37.8 °C)

Surface Tension: 25 dynes/cm, estimated

Water Solubility: Slightly soluble

Section 10 - Stability and Reactivity

Stability/Polymerization/Conditions to Avoid: Fuel oil no. 2 is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Heat and ignition sources.

Storage Incompatibilities: Include strong oxidizing agents.

Hazardous Decomposition Products: Thermal oxidative decomposition of fuel oil no. 2 can produce various hydrocarbons, hydrocarbon derivatives, partial oxidation products (carbon dioxide (CO₂), carbon monoxide (CO), sulfur dioxide (SO₂)).

Section 11 - Toxicological Information

Acute Oral Effects:

Rat, oral, LD₅₀: 12 g/kg.

Acute Skin Effects:

Rabbit, skin: 100 mL/kg/12 days, continuously, caused irritative dermatitis, weight loss or decreased weight gain, and death.

Rabbit, skin, LD: > 5 g/kg.

Irritation Effects:

Rabbit, eye, standard Draize test: 100 mg/30 seconds, resulted in mild irritation.

Rabbit, skin, standard Draize test: 500 mg/24 hr, resulted in moderate irritation.

Other Effects:

Tumorigenicity, mouse, skin: 243 g/kg/97 weeks, administered intermittently, caused skin and appendage tumors (carcinogenic by RTECS criteria).

See RTECS LS8930000, for additional data.

Section 12 - Ecological Information

Environmental Fate: Based on a calculated BCF (1.02×10^4 to 1.4×10^4), bioconcentration could be an important environmental fate process; however, it may be limited for the chief components of fuel oil no. 2 due to metabolism. It may biodegrade in water and soil, or volatilize from water (half-life of 4.4- 4.8 hours from a model river) and moist soil surfaces, but adsorption may attenuate the rate of these processes. In the atmosphere, fuel oil no. 2 will rapidly degrade by reaction with photochemically produced hydroxyl radicals (estimated half-life 1 day or less). A high K_{oc} indicates significant sorption and low mobility in the soil column. K_{oc} - 1×10^4 , estimated

Ecotoxicity: Juvenile American shad, TL₅₀/24 hr: 200 ppm; bluegill, LC₅₀ = 95 mg/L/96 hr; carp, LC₅₀ = 8.2 mg/L/24 hr; pumpkin seed, LC₅₀ = 1.9 mg/L/24 hr. Through its coating action, this material can pose a hazard to aquatic biota including water birds, plankton, algae and fish.

Henry's Law Constant: 29 to 68 atm-m³/mole at 77 °F (25 °C), estimated

Octanol/Water Partition Coefficient: log K_{ow} = 8.2 to 9.7

Section 13 - Disposal Considerations

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Material may be sprayed into an incinerator. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Hazardous Materials Table Data (49 CFR 172.101):

Shipping Name and Description: Fuel oil (No. 1, 2, 4, 5, or 6)

ID: NA1993

Hazard Class: 3 - Flammable and combustible liquid

Packing Group: III - Minor Danger

Symbols: D - Domestic transportation

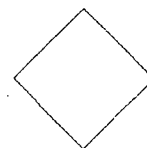
Label Codes: 3 - Flammable Liquid

Special Provisions: 144, B1, IB3, T4, TP1, TP29

Packaging: Exceptions: 150 Non-bulk: 203 Bulk: 242

Quantity Limitations: Passenger aircraft/rail: 60 L Cargo aircraft only: 220 L

Vessel Stowage: Location: A Other:



Section 15 - Regulatory Information

EPA Regulations:

RCRA 40 CFR: Not listed

CERCLA 40 CFR 302.4: Not listed

SARA 40 CFR 372.65: Not listed

SARA EHS 40 CFR 355: Not listed

TSCA: Listed

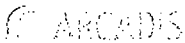
Section 16 - Other Information

Disclaimer: Judgments as to the suitability of information herein for the purchaser's purposes are necessarily the purchaser's responsibility. Although reasonable care has been taken in the preparation of such information, Genium Group, Inc. extends no warranties, makes no representations, and assumes no responsibility as to the accuracy or suitability of such information for application to the purchaser's intended purpose or for consequences of its use.

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Appendix H

Utility Locate Policy and Procedure

 ARCADIS	<u>ARCADIS HS Procedure Name</u> Utility Location Policy and Procedure	<u>Revision Number</u> 05
<u>Implementation Date</u> 13 December 2006	<u>ARCADIS HS Procedure No.</u> ARCHSFS019	<u>Revision Date</u> 22 February 2008
<u>Author</u> Michael Thomas	Page 1 of 10	<u>Approver</u> Mija Coppola

1. POLICY

It is the practice of ARCADIS and its affiliated companies to implement appropriate, reasonable and practical procedures within acceptable and customary industry practices to promote the health and safety of its employees, and avoid and mitigate exposure of risk in the performance of their work. In furtherance of this policy, ARCADIS promotes and encourages compliance by all employees with this policy and procedures relating to subsurface work and/or investigations (SWI) and working in the vicinity of above ground utilities.

- This procedure is followed by all responsible ARCADIS personnel. Such procedures are included in the Project Planning processes utilized by ARCADIS personnel.
- Project Management procedural requirements are outlined in Section 5.1. All employees included in SWI and above ground utility work are familiar with these procedures.
- For all SWI, it is required to contact the locality One Call number and/or a privately contracted utility location company, and to conduct a visual inspection of the site for subsurface utility locating. In addition, for non-greenfield sites, ARCADIS obtains from the client, a detailed site utility map. Additional lines of evidence may be required based on field conditions and client requirements for subsurface utility location. The project manager or designated representative in cooperation with the H&S staff and SWI contractor determine when and if additional lines of evidence are required. Additional lines of evidence include but are not limited to the following:
 - Detailed site utility maps, preferably “As-Built” drawings (drawn to scale)
 - Hand augering or digging
 - Hydro-knife
 - Air-knife
 - Radio Frequency Detector (RFD)
 - Ground Penetrating Radar (GPR)
- Contract Terms: In agreements for SWI with a client, prime contractor, or subcontractors, required terms (Exhibit 1) shall be included for the appropriate allocation of risk of damage to subsurface facilities. If such provisions cannot be agreed upon, the reasons are documented and other risk-management actions identified, such as limits of liability, additional physical investigations, additional lines of evidence of utility location, assignment of risk to subcontractors, etc.
- The policy of ARCADIS encourages and empowers all employees to take such action as they deem appropriate to assure compliance with this policy and procedures both in project planning and field site operations. Such authority is delegated to those on the project site to

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immediately stop any SWI work or work in the vicinity of above ground utilities where the employee believes that injury to persons or damage to property could occur. Such action is taken without regard to costs or schedule. Personnel immediately notify their supervisor of any concerns that they have in observing any SWI work or work in the vicinity of above ground utilities. In all agreements between ARCADIS and SWI subcontractors, (e.g., drilling subcontractors), provisions shall be included in the subcontract, work authorization or purchase order. These provisions (Exhibit 1) are found on the ARCADIS intranet at the Legal Department team site.

All ARCADIS personnel involved in SWI work or work in the vicinity of above ground utilities are appropriately trained on this procedure and have the appropriate professional experience for oversight of or involvement in SWI work or work in the vicinity of above ground utilities. ARCADIS Corporate Health & Safety can answer further questions about this policy or the hazards associated with and the control procedure for work in the vicinity of subsurface or above ground utilities.

Again, to support the efforts of ensuring the health and safety of its employees and mitigating risk to ARCADIS, ARCADIS requires that these policies and procedures be followed and implemented at all levels of project management and field implementation.

2. PURPOSE AND SCOPE

2.1 Purpose

This procedure directs general safety procedures associated with the identification and management of above ground and subsurface utility locations on project sites.

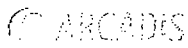
2.2 Scope

2.2.1 Management Requirements - ARCADIS personnel managing or working on any project requiring SWI and requiring work in the vicinity of above ground utilities must incorporate this procedure into their project planning and field work activities to ensure that all reasonable means to identify utilities are implemented and that appropriate controls have been put in place to minimize or eliminate damage to these utilities and the hazards associated with these utilities. All applicable procedures described in this document must be completed prior to initiating intrusive field work or field work in the vicinity of above ground utilities, or the work cannot proceed.

2.2.2 Project Management Requirements - Where SWI are required to be performed by a subcontractor to ARCADIS under its subcontract, project management shall require the subcontractor to adequately incorporate SWI procedures described herein into the subcontractor's scope of work.

3. DEFINITIONS

Above Ground Utilities - For the purpose of this procedure, above ground utilities include, but are not limited to: any above ground line, system, or facility used for producing, storing, conveying, transmitting or distributing communication or telecommunications, electricity, gas,

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petroleum and petroleum products, coal slurry, hazardous liquids or gases, water under pressure, steam, or other hazardous materials.

Subsurface Utilities - For the purposes of this procedure, subsurface utilities include, but are not limited to: any underground line, system, or facility used for producing, storing, conveying, transmitting or distributing communication or telecommunications, electricity, gas, petroleum and petroleum products, coal slurry, hazardous liquids or gases, water under pressure, steam, or sanitary sewage; underground storage tanks; tunnels and cisterns; and septic tanks.

4. RESPONSIBILITIES

4.1 Project Manager Responsibilities

To prevent injury to employees, avoid disruption to utility services, and help eliminate damage to subsurface and above ground utilities, project managers have the responsibility for utility identification, location, and marking prior to initiating field activities. Most states, provinces, municipalities, and clients have rules, general statutes, or laws that specify the requirements of subsurface utility location prior to intrusive subsurface field activities (i.e., excavation, trenching, boring, and all forms of drilling operations, etc.). The project manager ensures that these laws are followed, and that the directives outlined in this procedure are met for every project involving SWI and work in the vicinity of above ground utilities.

In addition, if field activities are completed in the vicinity of above ground utilities, the project manager is responsible for working with the client to identify the nature of the utilities, and to determine what control processes need to be implemented to prevent damage to these utilities and to minimize any injury in the event there is damage.

4.2 Field Personnel Responsibilities

Field personnel conducting SWI activities and activities where above ground utilities are in the vicinity of the work have the responsibility to read, understand, and follow this procedure and complete the appropriate checklists during the on-site utility locate process. ARCADIS personnel assisting in the identification of underground utilities have previous related experience of a minimum of 1 year. Those implementing remote sensing technologies have completed training in those techniques and have 6 months experience operating and interpretation results.

If utilities cannot be located to eliminate any reasonable concern, field personnel use their Stop Work authority until utility locations can be identified. Field personnel review this procedure onsite with ARCADIS subcontractors, and ensure they follow the procedures detailed in this document. Any ARCADIS subcontractor not following these procedures are asked to stop work, and the project manager contacted. Any diversion from this procedure by ARCADIS field personnel is approved by the project manager with input from Corporate Health and Safety as necessary.

5. PROCEDURES

5.1 Procedures

A flow chart/decision tree of these procedures is presented in Exhibit 2 of this document.

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5.1.1 Project Management Procedural Requirements

5.1.1.1 Planning and Information Request

Field activities are planned and designed to avoid contact with and damage to, and minimize interference with subsurface and above ground utilities in the vicinity of ARCADIS work activities. During the planning phase of a project the project manager contacts the client and/or property owner to request the following information for the area of the Site where the work will occur:

- A list of known or suspected existing and historical subsurface and above ground utilities present on a subject property;
- An accurate site plan (drawn to scale) illustrating subsurface and above ground utilities; and
- Construction, diameter, volume, depth, contents, and physical properties, etc. of each subsurface and above ground utility.

In the event that the client and/or property owner is not aware of the utilities at the subject property, can only provide a partial list, or cannot provide an otherwise accurate, scaled map, plan or drawing of utilities on the site, then additional resources are utilized to identify utilities at the subject property. This may include but are not limited to:

- Contacting utility provider billing departments directly to inquire if a bill is generated for the property address;
- Utilizing city/county computer-drawn maps, or geographical information systems (GIS) data containing utility information; and/or
- A site walk to visually inspect the subject property for evidence of subsurface and above ground utilities (i.e., manhole covers, meters, warning signs, vent pipes, fill ports, pipe runs, utility lines, etc.).

In the project planning process, the project manager and /or task manager determines the reasonable methods to be used to locate subsurface utilities prior to SWI. It is required to contact the state or province One Call number and/or a private utility locator if on private property as appropriate to the site. Also, an additional two lines of evidence are used for subsurface utility line location at all sites. If scaled and accurate site utility maps are not provided by the client, additional lines of evidence are used (see Section 5.0 for lines of evidence options). Increased flexibility is built into subsurface sampling and/or extraction programs when confidence in utility identification, location, and marking is less than optimal.

5.1.1.2 Communication and Coordination

Using list of identified and suspected utilities, the PM or their designated Task Manager:

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- Notifies a public one-call service centers and/or private utility contractors prior to initiating intrusive subsurface field activities;
- Provides the list to the site safety officer for inclusion in the site-specific health and safety plan (HASP);
- Communicates potential hazards to field staff prior to mobilization;
- Instructs field staff to be aware of and implement the procedures in the Section 6.2 of this procedure and utilize the appropriate utility location checklists.
- When practical, schedules a joint meeting between the public/private utility locators and field staff to oversee the subsurface utility locating and marking in the field.
- Communicates with and provides utility location documentation to the subcontractors to inform them of the utility locations and discusses methods to be used to protect those utilities.
- Understands the subcontractor's methods for utility location and documenting the process with a clear delineation of responsibilities for utility location.

In general, subsurface utility locations marked by public utility locators are only good for 2 weeks (research your state-specific requirements). If SWI activities are not conducted during this time period, the site is remarked. At no time is SWI conducted based on old markings, hand-drawn maps/sketches, photographs, or by recollection/memory of field staff. If markings are smeared, removed, damaged, or impacted in any way, the site must be remarked before SWI begins. Flag markings are used in addition to paint markings wherever possible.

5.1.1.3 Utility Request Notifications for Public Property

Prior to intrusive work on public property (i.e., right-of-ways, easements, etc.), notification of a public one-call service center is completed a minimum of 48-72 hours (states/localities requirements vary, so the PM is responsible for verifying this) prior to initiating field activities (excluding Saturdays, Sundays, and legal holidays). Specific state or local laws related to utility location are evaluated with respect to notification and liability in the event of utility damage. During the call, ARCADIS:

- Provides accurate description of the location of all areas of the SWI;
- Documents the utility locate request to record the time and date of the call, the area to be marked, the list of utility companies and municipalities that the one call service center will notify;

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- Records the associated ticket (or dig) number provided by the one call service center;
- Cross references the notification list provided by the one-call service center with the list of known or suspected utilities for the property; and
- Provides accurate contact (PM name and phone numbers) information for the one call service center so they can subsequently communicate potential questions and/or delays related to the utility location and marking.

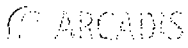
After receiving a request, the one-call service center sends requests to participating utility operators who have utilities in the area of the intrusive field activities. Each underground utility operator dispatches their own locators to mark their facilities with paint or flags. The project manager attempts to have field staff present during the marking of the utilities by the locator organization to ensure that the area of the SWI is included in the locating activities. It is important to note:

- Not all utility operators and municipalities participate in one call programs. In some instances, one-call programs provide a list of utility providers that participate, and a list of those that do not. The utility providers that do not participate are contacted individually so that they can mark their own lines, and ARCADIS documents this call (date of call, person receiving call, date lines will be marked, etc.);
- Public utility locators are usually only required to mark utilities within the public spaces (i.e., right of ways) or at most up to a meter on private property; and
- Knowledge of existing or suspected, but unmarked utilities are documented and communicated to the site safety officer, field staff, and the client prior to implementing field activities.

If a known or suspected subsurface utility does not participate in the state one-call program, and that provider has not been individually contacted prior to the start of SWI, then the field activities are postponed. If these utility providers are contacted and do not provide utility location services, then SWI are not performed until a private utility locating company is contracted and the locating tasks completed. If utility locates are not completed by public or private utility locating companies, then the subsurface activities are performed with extreme care using hand tools, or other means of utility location are used (air knife/hydro-knife technologies, or GPR), but only upon receiving approval from the ARCADIS Health & Safety department and the client.

5.1.1.4 Utility Request Notifications for Private Property, Military Installations, or Other Government Facilities

Prior to intrusive work on private property, military installations, or other government facilities the public one call service center is contacted as previously described, to identify utilities that enter and/or are in the vicinity of the subject property. In addition,

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- A private utility contractor may be required to locate and mark utilities that transect the property beyond meters and/or additional utilities that property owner has installed, which may or may not be maintained and serviced by a utility or municipality
- Where appropriate, or at a client's request, a facility or plant engineer familiar with the subsurface utilities is contacted to request marking and location of utilities
- One or more weeks of advanced notice is usually required to subcontract a private contractor or coordinate with a facility or plant engineer to locate and mark utilities
- Verbal or written requests to private contractors or onsite personnel for utility location and marking is documented to record the time and date of the request, the area to be marked, and the list of utilities to be marked
- The project manager attempts to have field staff present during the marking of the utilities by the locator organization to ensure that the area of the SWI is included in the locating activities
- Knowledge of existing or suspected, but unmarked utilities is documented and communicated to the site safety officer, field staff, and the client prior to implementing field activities
- If a known or suspected utility is not located and marked by the private utility company or facility engineer, then sampling and/or excavation activities is performed with extreme care using hand tools, hydro-knife or other method that does not damage the utility; postponed until utilities are clearly marked; or canceled. If work proceeds, it can only be completed with the approval of the ARCADIS Health and Safety department and the client.

5.1.1.5 New Nation-wide Utility Locate Call Number 811

Several state and local utility notification centers have launched a new "Call before you Dig" number to help save lives and protect underground infrastructure. This new, national number is: **811**. The number is designed to help prevent professional excavators, drillers, etc. and homeowners, from damaging underground utility lines while digging/drilling and causing injury or service outage. For more information about the 811 services, visit www.call811.com

The number 811 is a new FCC designated national n-11 number created to eliminate confusion of multiple calls before you dig numbers across the country. This quick and efficient one call service will notify the appropriate utilities, who participate in the one call program. **However**, ARCADIS callers must still verify who the one call service contacts, and then determine which utilities may need to be contacted directly (e.g. those utilities not participating in the one call service) by following the requirements outlined in this procedure.

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5.1.2 Field Protocol

At no time do field activities that involve SWI or work in the vicinity of above ground utilities commence without the field staff having knowledge of the location of subsurface and above ground utilities. In addition, as stated above and in general, subsurface utility locations marked by public utility locators are only good for 2 weeks (research your state-specific requirements). If SWI activities are not conducted during this time period, the site is remarked. At no time is SWI conducted based on old markings, hand-drawn maps/sketches, photographs, or by recollection/memory of field staff. If markings are smeared, removed, damaged, or impacted in any way, the site must be remarked before SWI begins. Flag markings are used in addition to paint markings wherever possible.

5.1.2.1 SWI and Subsurface Utilities

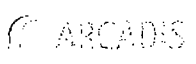
Prior to the start of intrusive activities, all utilities are located and measures instituted to avoid subsurface utility hazards. If intrusive work must take place within close proximity to a utility line, the utility line can also be rendered controlled (i.e. through lockout/tagout procedures).

Prior to mobilizing to the site for SWI work, field staff reviews the task details with the project manager or their designated authorized TM. This may include but is not limited to review of boring logs, excavation permits, etc. Any special site or client requirements are also discussed. Prior to initiation of any intrusive activities, the utilities and structures checklist (Exhibit 3) is reviewed and completed. Generally, the following colors apply for different types of utilities/operations:

In addition, the SWI subcontractor marks (i.e., paint, stakes, etc.) the location of their operations to ensure they fall within the area that has been investigated for utilities.

Once the checklist is completed and all utilities identified, any client/site specific utility location or other utility (subsurface or above ground utilities) protection procedures (i.e. such as hand digging to a specified depth, covering or shielding lines, etc.) is completed at each location where work will be completed. If a known or suspected public subsurface utility has not been marked or the markings are not clear, the state one-call number is contacted to determine if an "emergency" locate can be requested. If so, follow the procedures outlined by the locate service and contact the project manager. If it is a private utility that is not marked, the facility manager and/or the project manager should be contacted.

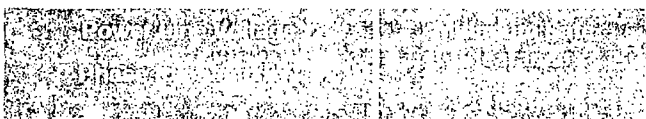
If uncertainty remains on utility location, and/or more precise locations of utilities are required, and where field staff determine the circumstances warrant it, additional lines of evidence are implemented including air or hydro knifing, or ground penetrating radar. Descriptions of the use and limitations of these methods are included in Exhibit 4.

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If unexpected conditions are encountered (refusal, debris, pea gravel, etc.) while completing the intrusive activity, all work is immediately halted. Note that subsurface utilities at many industrial facilities are often placed in conduits or concrete to prevent damage. If a utility or subsurface structure is compromised, the field staff initiates the Emergency Action Plan Guidelines (Exhibit 5); however, more detailed emergency action procedures should be reviewed with the client and documented in the site specific health and safety plan prior to initiating work.

5.1.2.2 Work in the Vicinity of Above Ground Utilities

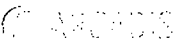
If activities take place in the vicinity of an above ground utility, the utility line can be rendered controlled (i.e. through lockout/tagout procedures) or protected from damage (i.e. covering overhead power lines). The following table is used to develop acceptable work distances for work involving machinery with high extensions (backhoes, drilling rig masts, etc.) in the vicinity of overhead power lines:



ANSI Standard B30.5-1994, 5-3.4.5

The distance may be lengthened if directed by the client or the electric company, and any specified distances are strictly followed. In addition, work involving machinery, vehicles or equipment that may come in contact with above ground utilities is not completed until those utilities are protected or control processes are in place to avoid damage to those utilities.

If an above ground utility is discovered that has not been previously identified prior to mobilizing to the field, the field staff notifies the project manager who requests the client to assist in the identification of the utility and the implementation of control procedures as appropriate. In addition, if a utility or subsurface structure is compromised, the field staff initiates the Emergency Action Plan Guidelines (Exhibit 5); however, more detailed emergency action procedures should be reviewed with the client and documented in the site specific health and safety plan prior to initiating work.

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6. RECORDS

6.1 Checklist Records

7. APPROVALS AND HISTORY OF CHANGE

Approved By: Mija Coppola, Director H&S Compliance Assurance, LPS

History of Change

Revision Date	Revision Number	Reason for change
13 December 2006	01	Original document
26 March 2007	02	Put in new company format
15 May 2007	03	Added nation-wide 811 number
6 September 2007	04	Changing over to new template format
22 February 2008	05	Changing over to new template format

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Exhibit 1 - Contract Term Language

Site Conditions: ARCADIS shall not be liable for: (i) damage or injury to any subterranean structures (including, but not limited to, utilities, mains, pipes, tanks, and telephone cables) or any existing subterranean conditions; or the consequences of such damage or injury, if (with respect to this clause (i)) such structures or conditions were unknown and were not identified or shown, or were incorrectly shown, in information or on plans furnished to or obtained by ARCADIS in connection with the Services; (ii) concealed conditions encountered in the performance of the Services; (iii) concealed or unknown conditions in an existing structure at variance with the conditions indicated by the Scope of Services or Work Authorization; or (iv) unknown physical conditions below the surface of the ground that differ materially from those ordinarily encountered and are generally recognized as inherent in work of the character provided under this Agreement.

Client shall provide to ARCADIS all plans, maps, drawing and other documents identifying the location of any subterranean structures on the Site. Prior to location of any drilling or excavation below the ground surface, ARCADIS shall obtain the concurrence of the Client as to the location for such drilling or excavation.

Should: (i) concealed conditions be encountered in the performance of the Services; (ii) concealed or unknown conditions in an existing structure be at variance with the conditions indicated by the Scope of Services or Work Authorization; or (iii) unknown physical conditions below the surface of the ground differ materially from those ordinarily encountered and generally recognized as inherent in work of the character provided under this Agreement; then the amount of this Agreement and/or time for performance shall be equitably adjusted by change order upon timely notice.

Site Conditions: SUBCONTRACTOR acknowledges that time is of the essence with respect to the performance and completion of its work under this Contract. SUBCONTRACTOR shall adhere to, commence and complete its work in accordance with any schedule incorporated into this Contract, or any schedule submitted by SUBCONTRACTOR or attached hereto; and with respect to any Changes, out of scope or additional work, SUBCONTRACTOR shall expeditiously perform such work according to any schedule therefore agreed to by the parties. In the event any schedule is incorporated in this Contract or attached to this Contract, SUBCONTRACTOR acknowledges and agrees that such schedule has accounted for all inherent or reasonably anticipated delays, including but not limited to those inherent in obtaining site information, access sufficient labor, supplies, tools, equipment and utilities required for the project work, and SUBCONTRACTOR waives any claim of extra compensation or damages therefore.

Subcontractor represents and warrants that it has had an opportunity to review and/or has carefully examined all necessary drawings, maps, schematics, specifications, governmental restrictions, permits and license requirements, and all applicable laws, regulations and rules relating to the Work to be done and the Site, its surroundings and local conditions, and has made all investigations based on reasonably available information that are necessary to develop a full understanding of the hazards and difficulties which can be encountered and are likely to impact the cost or schedule to perform the Work. SUBCONTRACTOR is thus familiar with conditions at the Site as are pertinent to or which may affect the Work and has been granted the right to

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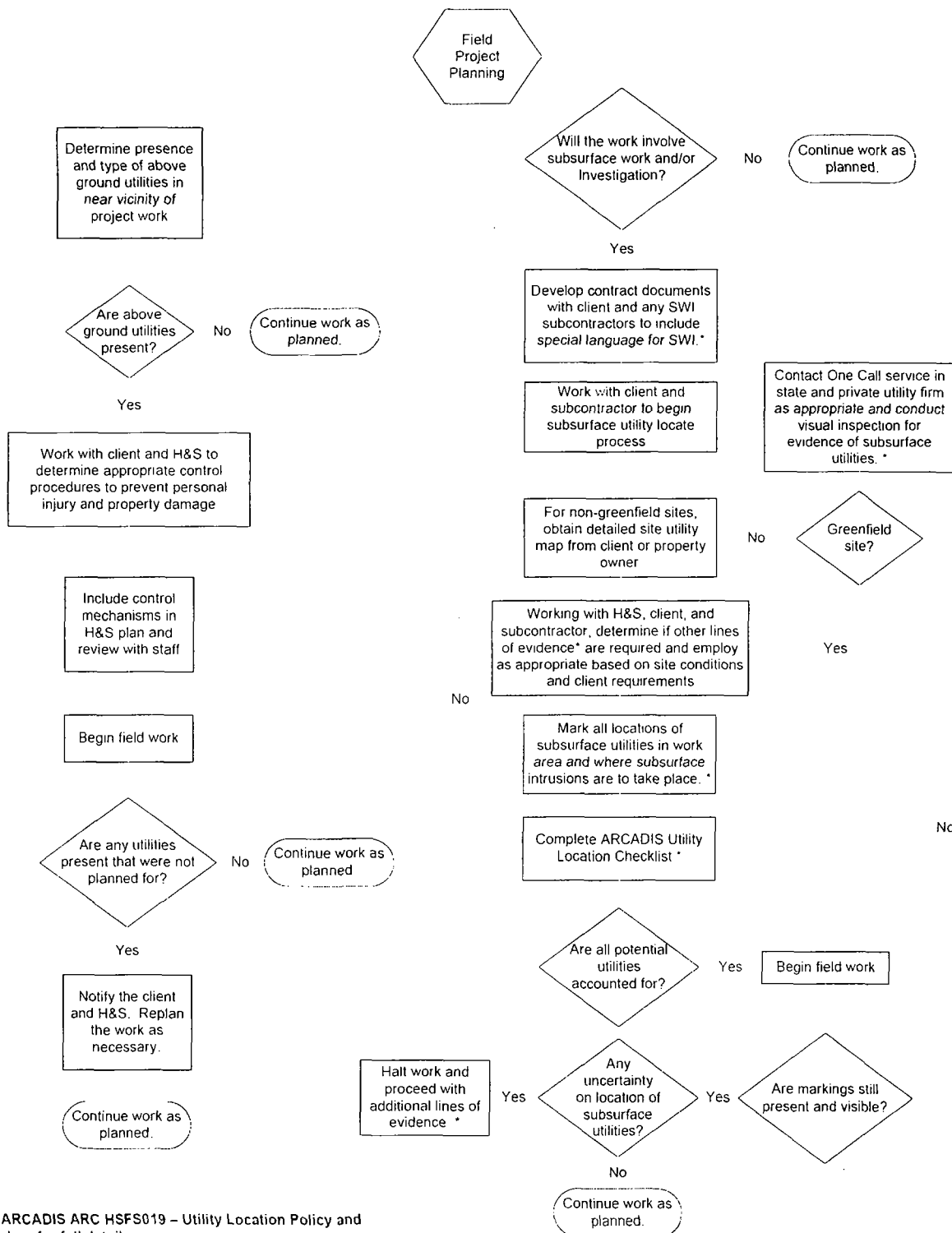
conduct, and has conducted, all investigations it deems appropriate to determine that it can fulfill the requirements of this Contract. Notwithstanding any other provision of this Contract, SUBCONTRACTOR assumes the risk of all conditions, as specified in this Contract, that may affect SUBCONTRACTOR'S ability to perform the Work and will, regardless of such conditions, or the expense or difficulty of performing the Work or the negligence, if any, of ARCADIS, with respect to same, fully complete the Work for the stated price without further recourse to ARCADIS. Information on the Site and local conditions at the Site furnished by ARCADIS are not guaranteed by ARCADIS to be accurate, and is furnished only for the convenience of SUBCONTRACTOR.

The discovery of concealed conditions which could not reasonably have been anticipated by the SUBCONTRACTOR from information available to SUBCONTRACTOR may constitute a changed condition, which, to the extent such condition materially affects the cost or schedule to perform the Work, would entitle the SUBCONTRACTOR to a change and an equitable adjustment of the Contract price or time. SUBCONTRACTOR warrants that it shall conduct appropriate investigations to determine, with reasonable certainty, the location of utility and service lines, underground storage systems, and other subsurface structures of any kind before commencement of any drilling, excavation, or other work that has the potential to disturb these structures. SUBCONTRACTOR further warrants that it shall conduct independent field investigations to confirm the location of subsurface structures before commencement of subsurface work and shall not rely exclusively on plot plans or other drawings provided to SUBCONTRACTOR in conducting these investigations.

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Exhibit 2 – Utility Location Decision Tree

Exhibit B- Utility Location Decision Tree*
(PMs or TMs are required to follow both sides of flowchart)



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Exhibit 3 - Utilities and Structures Checklist

Project:	Project Number:
Site Location:	Date:

Instructions: This checklist will be used as a safety measure to insure that all underground utility lines, other underground structures as well as above ground utilities are clearly marked out and identified in the area selected for boring or excavation. **DRILLING, EXCAVATION, OR ANY TYPE OF GROUND INTRUSIVE WORK MAY NOT PROCEED UNTIL LINES ARE MARKED AND THIS CHECKLIST HAS BEEN COMPLETED.**

Pre-Field Work Requirements		
Was the state one-call notified with the required advanced notice (usually 48 to 72 hours)	YES	NO
State one-call confirmation number		
What are the 2 lines of evidence used for utility clearance?		
Was a plot plan showing site features and subsurface utilities provided by the PM/TM?	YES	NO
Was the Nation-wide 811 Number called? If no, why not?	YES _____ NO _____	
If yes, what information was provided?		
Subgrade Utility Line Location		
Where is the gas line located?		
Where is the gas meter located on the site building(s)?		
Are the electric lines subsurface or overhead? Where are they located?		
Where is electric meter located on the site building(s)?		
Where are the telephone/cable lines located? Are there any overhead lines?		
Where do these lines enter the site building(s)?		

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Where are the water lines located?	
Does the site occupant use water (bathrooms, industrial uses, fire suppression, etc.)? If so where do the water lines enter the building for these purposes?	
Are there small manholes/vault covers indicating water lines? If so, where?	
Was the local municipality contacted to mark sanitary lines?	
Where are the sanitary lines located?	
Where might the sanitary lines enter the building? (i.e. what side of the building are the bathrooms, kitchens, water treatment plant, etc?)	
Where are the storm sewer lines located?	
Are there storm sewer inlets located on the property? Check inlets for direction of subsurface lines.	
Are there any gutters directing storm water to the subsurface? Evaluate for direction of lines.	
Underground Storage Tank Sites	
Where are the USTs located? How many USTs are at the site (very number of USTs by counting fill ports and vent lines)?	
Where do the vent lines run?	
Where does the piping run? (Evaluate the path between USTs to dispenser islands).	
Where are the sub-surface electrical lines located which feed power to the UST system?	
General Underground Utility Location Signs	
Are there any cracks resembling straight lines that may indicate the settling of utility lines?	
Are there any patched areas where subsurface repairs may have been conducted?	
Are there any manhole covers or valve boxes that are not associated with marked lines?	

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Above ground Utility Line Location	
Are there overhead power lines? If, so where are they located?	
What is the voltage of the overhead power lines?	
Are there any above ground structures (utilities, piping, etc.) that are used by the client? If so, are they located proximal to the work area?	
Do these lines need controlled (locked out) or protected prior to starting work?	
Interviews: Site Owners/Occupants MUST be interviewed for location of private utility lines at the site (if practicable) before start of work	
Name of Owner/Occupant.	
How is this person affiliated with the Site?	
Who interviewed Owner/Occupant?	
Date of Interview	
Specific comments that should be noted from the interview:	

NOTE: If any subsurface utilities listed above are not located, do not proceed with subsurface activities. Contact PM/TM immediately.

Name and signature of person who conducted utility line checklist

Name (print)

Signature

Date

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Exhibit 4 - Use and Limitations of Utility Locating Methods

Ground Penetrating Radar (GPR)

The GPR system transmits high frequency electromagnetic waves into the ground and detects the energy reflected back to the surface. Energy is reflected along boundaries that possess different electrical properties. Reflections typically occur at lithologic contacts or where subsurface materials have high electrical contrasts, including metal objects such as underground storage tanks (USTs), drums, and utility pipes. These reflections are detected by the antenna and are processed into an electrical signal that can be used to image the subsurface feature. The GPR data will be reviewed in the field to assist in the delineation of potential piping or other subsurface structures.

The detection of subsurface structures located at the site depends on the electrical properties of the soil and the structure's depth, diameter, and composition. GPR is limited to the detection of smaller diameter pipes with depth. Generally, a pipe must increase in diameter by one 1 inch for each foot in depth to be seen using GPR. Also, plastic piping is more difficult to detect than metal piping using GPR, and caution should be used if plastic utility lines are suspected.

Radio Frequency Detection (RFD)

This instrument operates on the principle of radio frequency transmission and detection. The transmitter applies a known frequency to the pipe and the receiver is able to detect this frequency along the length of the structure. The success of RFD in tracing underground utilities is based on the composition of the structure (metal or plastic) and the ability to accurately position the transmitter unit so that it can be attached to, or placed directly over the structure. RFD should only be used to verify the location of utility mark-outs, and not as the primary method of utility identification.

Soil Vacuum Excavation

This method uses *nondestructive vacuum excavation methods* to create a visual test hole allowing the confirmation of buried utilities. This method is very accurate and relatively fast and can be performed prior to or during the drilling program. The limiting factors for this method are cost and availability. As with specialty drilling methods, a limited number of firms have the equipment to perform vacuum excavation.

The location of the structures to be cleared relative to the source and depth of impacted soil or groundwater is considered. If the zone to be cleared is known not to contain hazardous vapors or petroleum hydrocarbons via previous testing, continuous air monitoring is implemented using a lower explosive level (LEL)/O2 meter and photoionization detector (PID) or flame ionization detector (FID) to the depth of the boring. Also consistent with the site health and safety plan (HASP), air monitoring should be conducted continuously with the LEL/O2 meter during any activity if flammable or explosive vapors are suspected to be present. Prior to any subsurface investigation activities, air monitoring should be conducted to establish background levels for total organic vapors using a PID or FID. All work activity must STOP where tests indicate the concentration of flammable vapors exceeds 10% of the LEL, and the source of vapors must be investigated.

Vacuum-assisted soil excavation utility clearance will not be used in areas know to contain hazardous vapors or petroleum hydrocarbons unless the equipment to be used is suitable for flammable/explosive atmospheres. There is a significantly increased risk of explosion if these

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materials are encountered while performing this type of utility clearance. Cautions will be performed, as identified below.

Cautions

Many vacuum systems that are commonly used for utility clearance are considered unsuitable for use for environmental investigation sites. Most vacuum units are "Not for use with Hydrocarbons, Explosives, Corrosive or Toxic Material," and are "Not Intrinsically Safe."

Given that many units and associated tanking are not explosion-proof, the following steps will be considered prior to using vacuum- assisted utility clearance units where soils could be impacted with petroleum hydrocarbons or flammable vapors.

1. Request from the manufacturer and/or the contractor doing the work to supply manufacturers' documentation and specifications for use of the unit at environmental sites.
2. Request documentation that the unit is intrinsically safe and may be used in areas where petroleum hydrocarbon may be present.
3. Obtain the procedures for grounding portable units to discharge potential static electricity during operation.
4. If none of the above are available, then hand auger instead and do not use vacuum-assisted methods.

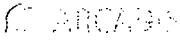
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Exhibit 5 - Emergency Action Plan Guidelines

When work activities result in the contact or compromise of a utility line, an appropriate response is critical to prevent injury, death or significant property damage. Although circumstances and response vary depending on site specific conditions, the following guidelines provide information that is factored into emergency action planning associated with utility damage. In any event, emergency planning is coordinated with the entity that owns the utility and the client prior to the start of work. This planning and the appropriate response actions are documented in the project health and safety plan and reviewed with all field staff.

Contact with Above or Underground Electric

Contact with above ground or underground electric lines may result in the equipment being energized. Field personnel do not assume rubber tires on equipment are insulating the equipment from the ground. For underground electric strikes, contact with the line may not be immediately noticeable but indications of a strike include: power outage, smoke, explosion, popping noises, or arching electricity. If contact with an electric line is made or is suspected, the following guidelines are followed:

- Under most circumstances, the equipment operator or any worker on a seat of the equipment should stay on the equipment. These workers should not touch anything, especially metal, on the equipment.
- If it is determined that the equipment should be vacated due to a life threatening circumstance, the worker(s) should jump clear as far as possible from the equipment. When jumping keep both feet together and hop away to a safe distance after landing on the ground. Do not use hand holds or touch any part of the equipment when preparing to jump off.
- Workers on the ground should move away from the equipment.
- Keep others away from the equipment and the area.
- If anyone is injured and in contact with the line or equipment, any attempted rescue should be performed with extreme caution. Only use long, dry, clean, unpainted pieces of wood or fiberglass pole or long dry, clean rope to retrieve the victim. Perform first aid/CPR only after the victim is sufficiently clear from the electrical hazard.
- Notify the electric utility or the client as appropriate for the site. Call 911 or the client's emergency response phone number, as appropriate, for any serious injury or any situation that may result in fire or other hazard that could produce injury or property damage.

Natural Gas

If a natural gas line of any size is compromised, immediately:

- Shut off the equipment and remove any other ignition sources.
- Evacuate the area as quickly as possible.

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- DO NOT attempt to turn off any gas valves.
- Call 911 or the designated client emergency response number as appropriate.
- Call the gas utility, if site response is not controlled by the client.
- Do not return to the area until permitted by the utility or by the approved client emergency response personnel, as appropriate.

Water Lines (all types)

Compromised water lines may rapidly become a significant hazard especially if the line is under considerable pressure. Ruptured pressurized water lines may undermine and wash out unconsolidated materials beneath equipment or structures causing them to become unstable. If a pressurized water line is ruptured, the following guidelines should be followed:

- Promptly shut off all equipment.
- Lower masts or other high extension components of the equipment.
- Evacuate area and call the water utility or client emergency response number, as appropriate.
- Turn off the water if the valve location is known and on the site property.
- If potable water lines have been ruptured, attempt to divert any flow away from structures prone to being flooded. Use caution and keep a safe distance from the line break since the ground surface may be compromised.
- For raw process water or other water of unknown quality, do not attempt to divert or contain. Avoid skin contact or accidental ingestion of any water.
- When returning to the area of the break, survey the area for signs of compromised land surface (cracks in asphalt or concrete, depressions in ground, observations of undercutting, etc.) and avoid moving any equipment until these conditions are repaired or resolved.

Sewers (all types)

Use the same general guidelines for water lines when responding to compromised sewers. If a sanitary sewer is compromised additional guidelines should be followed to avoid contracting any bacterial illnesses. These include:

- Promptly evacuate the area.
- Avoid contact with any sewage material.
- If contaminated, promptly wash with soap (antimicrobial) and water and promptly change impacted clothing.

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- If sewage is accidentally ingested or infiltrates any breach of the skin or enters the eyes, seek medical attention as a precautionary measure.
- Decontaminate equipment with commercially available disinfectant solutions or a 10% chlorine bleach solution.

Communication Lines

Contact and compromise of communication lines are generally considered more of a financial concern than a concern associated with injury. However, eye damage may occur if looking into the ends of a cut fiber optic line. Do not look into the ends of fiber optic lines or other communication lines of unknown type. Promptly contact the communication company owning the line.

Product Lines and Underground Storage Tanks (all types)

Compromise of a product line or underground storage tank (UST) requires immediate action to mitigate impact to the environment. For gasoline stations and similar facilities the following guidelines should be followed during a line or UST breach:

- Immediately shut down equipment and turn off the emergency shutoff switch for the facility dispensers.
- If there are no injuries, attempt to contain any flowing product using absorbent materials and/or by physically pumping or bailing product out of the breached area.
- If product is flowing on the surface away from the break area, attempt to protect downgradient storm drains, sewer drains, and surface water features from impact of the petroleum product using any readily available materials.
- If the bottom of a UST has been breached, immediately contact a pump truck to remove product from the affected UST.
- For releases involving diesel fuel, care will be taken to avoid any situation where diesel may be injected into the body from impalement by coated nails, wood splinters, etc. If diesel is injected into the body, seek prompt medical attention, even if no apparent symptoms of a problem exist.
- Clear area and arrange for prompt repair.

For industrial sites with lines or USTs containing multiple products with varying hazards, similar guidelines may be followed as above if the material encountered is known and workers have a fundamental understanding of the hazards associated with the material. Upon discovery of a line or UST breach due to work activities at these sites:

- Immediately stop work and notify the client representative or call the client designated emergency number. For abandoned sites call 911.

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- If the material is not known, promptly evacuate the area and let HAZMAT teams deal with the release.

ARCADIS

Appendix I

Lead Policy and Procedure

Lead – Health and Safety Policy and Procedures

ARCADIS SOP: ARC HSIH010

Revision #2

Revision Date: 6 September 2007

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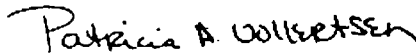
7.0 Records

Lead – Health and Safety Policy and Procedures**Approval Signatures**

Approved by:

Michael A. Thomas, CIH, Corporate HS Director

Approved by:



Revision Date	Revision Number	Reason for change
26 March 2007	01	Original document
6 September 2007	02	Changing over to new template format

Corporate HS Manager

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1.0 Policy

ARCADIS understands the hazards of personal exposure to lead. Based on this understanding, ARCADIS will implement the appropriate controls to minimize or eliminate the hazards of lead. These controls will focus first on engineering controls to mitigate lead hazards where appropriate and practical. Administrative controls may also be implemented as appropriate and practical. Where it is not appropriate or practical to implement engineering and administrative controls, personal protective equipment (PPE) will be implemented to control lead hazards below known occupational exposure limits.

2.0 Purpose and Scope

2.1 Purpose

2.1.1 **Exposure to Lead** - This policy and associated procedures provides information to protect ARCADIS employees, subcontractors, and other effected personnel from exposures to lead while conducting work on ARCADIS projects.

2.1.2 **OSHA Standards** – This policy meets the requirements of the U.S. Occupational Safety and Health Administration (OSHA) regulations including Title 29 Code of Federal Regulations (CFR) Part 1910.1025 and Part 1926.62

2.2 Scope

This policy and the associated procedures apply to all projects where lead is known or thought to be present, and where ARCADIS employees, subcontractors and other effected personnel are or could be exposed to lead above the Action Level.

3.0 Definitions

Action Level is the airborne concentration established by OSHA that triggers certain regulatory requirements.

Authorized person means any person authorized by ARCADIS and required by work duties to be present in lead regulated areas.

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. Lead can be found in all parts of our environment. Much of it comes from human activities including burning fossil fuels, mining, and manufacturing.

Lead has many different uses. It is used in the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays. Because of health concerns, lead

from gasoline, paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years.

Lead is encountered on ARCADIS projects as a contaminant in soils, ground and surface water, sediments, and other environmental media. It can also be encountered through the air where dusts containing lead are present. Personnel may also encounter lead in other forms at certain client facilities at which ARCADIS works. It can be encountered at mining and smelting operations, battery manufacturing facilities, chemical production facilities where metal coatings or plastics are manufactured and other types of industrial sites. In addition, other activities that may expose ARCADIS staff to lead include:

- Demolition or salvage of structures where lead or materials containing lead are present;
- Removal or encapsulation of materials containing lead;
- New construction, alteration, repair, or renovation of structures, substrates, or portions thereof, that contain lead, or materials containing lead;
- Installation of products containing lead;
- Lead contamination/emergency cleanup;
- Transportation, disposal, storage, or containment of lead or materials containing lead on the site or location at which construction activities are performed, and
- Maintenance operations associated with the construction activities described in this paragraph.

High-efficiency particulate air [HEPA] filter means a filter capable of trapping and retaining at least 99.97 percent of mono-dispersed particles of 0.3 micrometers in diameter.

Permissible Exposure Limit (PEL) is an average airborne concentration regulatory limit established by OSHA above which requires control to protect people from adverse health effects.

Short Term Exposure Limit (STEL) is a PEL or TLV established as a limit of exposure measured over a designated period of time less than 8 hours.

Threshold Limit Value is a recommended average airborne concentration limit established by ACGIH. The TLVs are reviewed and updated as appropriate annually.

Time Weighted Average (TWA) is a measurement of airborne exposure to a chemical compound measured and averaged over a designated period of time for comparison to an STEL or an 8-hour PEL or TLV.

4.0 Responsibilities

4.1 Project Managers are responsible, as part of the project hazard assessment, for determining if lead is or is potentially present on a project site. In addition, the project manager is responsible for determining client requirements with respect to the control of lead hazards. Project Managers notify health and safety staff when working on sites containing lead. Project Managers are also responsible for ensuring that project staff has the appropriate and applicable training for lead prior to those staff beginning work.

4.2 Corporate Health and Safety is responsible for keeping this policy and procedure up-to-date with current regulatory requirements and best practices. In addition, Corporate Health and Safety oversees the medical surveillance program for lead, as applicable and provides a lead training package to for presentation to appropriate staff.

4.3 Project Health and Safety Staff including designated Writers and Reviewers of Project Health and Safety Plans (HASPs) are responsible for developing control processes and techniques on specific projects based on the levels of lead expected to be encountered on project facilities.

4.4 Regional and Division HS Staff are responsible for supporting and assisting the project and task managers, and the project HS staff in the implementation of this policy and the associated procedures.

4.5 Project Personnel are responsible for completing lead training as required by this policy and procedure, and for following all hazard control processes designated by the Project Manager, Project Health and Safety Staff, and the project HASP. If project personnel believe that lead is present that was not previously identified or is at levels that are higher than expected, they should stop work and notify project health and safety staff or the project manager immediately and not proceed until authorized.

5.0 Procedure

5.1 Procedure

5.1.1 Lead Hazards

The health effects of lead are based on the type of exposure encountered by workers.

The primary route of exposure to lead in the work place is through inhalation of airborne lead. However, oral ingestion may represent a major route of exposure in contaminated workplaces. Most exposures occur with inorganic lead. Organic (tetraethyl and tetramethyl) lead, which was added to gasoline until the late 1970s, is not commonly encountered. Organic forms may be absorbed through the skin, while inorganic forms cannot.

Inorganic lead is not metabolized, but is directly absorbed, distributed and excreted. The rate depends on its chemical and physical form and on the physiological characteristics of the exposed person (e.g. nutritional status and age). Once in the blood, lead is distributed primarily among three compartments – blood, soft tissue (kidney, bone marrow, liver, and brain), and mineralizing tissue (bones and teeth). Absorption via the gastro-intestinal (GI) track following ingestion is highly dependent upon presence of levels of calcium, iron, fats, and proteins.

5.1.2 Exposure Limits and Regulated Areas

The following personal exposure limits are established for lead by inhalation:

- OSHA ACTION LEVEL – 30 micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$) lead in air 8-hour time weighted average (TWA).
- OSHA PERMISSIBLE EXPOSURE LEVELS (PELs)
 - TWA - 50 $\mu\text{g}/\text{m}^3$ lead in air averaged over an 8 hour period.
- ACGIH THRESHOLD LIMIT VALUES (TLVs)
 - TWA – 50 $\mu\text{g}/\text{m}^3$ lead in air averaged over an 8 hour period.
- Personal exposure is the concentration of lead to which a person would be exposed if that person were not wearing respiratory protection. Personal exposures shall be measured over the exposure period in the breathing zone of the employee. Personal exposures should not be determined by area sampling.

- REGULATED AREA

An area where the lead exposure does or can be expected to exceed the PEL. Since it may be difficult to determine the exposure time for employees working in areas with concentrations that exceed PEL values, the facility/location may wish to regulate any area that exceeds the 8-hour TWA PEL.. Only Authorized Persons are permitted to enter regulated areas.

5.1.3 Actions for Employee Exposures Greater Than or Equal to the Action Level but Less Than the PELs

- Training – Annual lead training is required.
- Medical Surveillance – Initial and annual medical exams (see below) are required if employee personal exposures do or can be reasonably expected to exceed the Action Level on at least 30 calendar days during the coming year.
- Periodic Monitoring – shall be conducted at least annually until at least two consecutive exposure determinations (no less than 7 days apart) indicate the exposure is below the Action Level.

5.1.4 Actions for Employee Exposures Greater Than PELs

- Respiratory Protection – a minimum of full face air-purifying respirators equipped with HEPA filters shall be used in all regulated areas.
- Training – Annual lead training is required.
- Medical Surveillance – Initial and annual medical exams (see below) are required if employee personal exposures do or can be reasonably expected to exceed the PEL on a least 10 calendar days during the coming year.
- Written Program – A written program to reduce personal exposure is required detailing the methods to be used to reduce exposures below the PEL. These written programs will be in the form of the project HASP based on project-specific and client requirements. The HASP will indicate the schedule for the implementation of the any lead-related hazard control processes or methods. The HASP is reviewed periodically but at least annually per the ARCADIS SOP ARC HSFS010 – Health and Safety Plans. All project personnel have access to the project HASP at all times.
- Periodic Monitoring – at least every 6 months until at least two consecutive exposure determinations (no less than 7 days apart) indicate the exposure is below the PEL; then

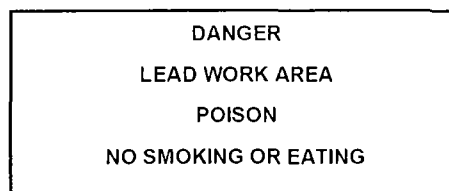
annually until at least two consecutive exposure determinations (no less than 7 days apart) indicate the exposure is below the PEL Action Level.

5.1.5 Exposure Monitoring

- Representative personal exposure monitoring is required for each type of operation involving the handling of or potential exposure to lead.
- Initial monitoring can be omitted if there is documented data or industrial hygiene calculations to demonstrate that exposures are below the action level.
- Personal exposure monitoring shall utilize standard industrial hygiene sampling techniques and recordkeeping.
 - Employees who have been monitored for lead exposure shall be notified of the monitoring results within 15 working days of receipt of these results. If the PEL is exceeded, the notification must indicate the follow-up plans or corrective actions to be taken to reduce exposures to below the PEL.
- Personal TWA monitoring can be used for extended tasks, such as soil and sediment sampling, working on mine sites where lead is present, where clients require monitoring, etc.
- Area sampling can be used to determine regulated areas;
- Periodic Monitoring is required if exposures exceed the Action Level or PELs.

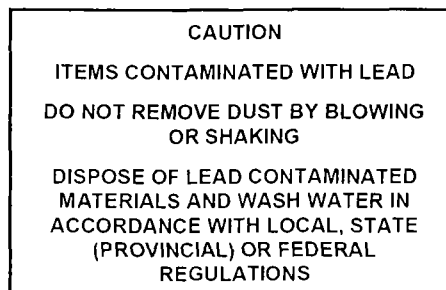
5.1.6 Requirements for Regulated Areas

- Posting – Regulated areas shall be indicated such as by barricades, barricade tape, painted demarcations, or other devices.
- A sign shall be posted at the access to the regulated area with the warning:



[Minimum lettering height: DANGER LEAD WORK AREA 4"; others 3"]

- Respiratory Protection – Respirators shall be worn by all personnel when in a regulated area, regardless of the time period or over-all personal exposure measurement.
- Labeling:
 - In addition to appropriate Hazard Communication labeling, containers or equipment containing lead or lead compounds must also be labeled as such:



- Eating, drinking, smoking, chewing any item, or applying cosmetics is strictly prohibited in a lead regulated area.

5.1.7 Exposure Reduction

- Written Program:
 - The Project Manager and the Project Health and Safety Staff will develop a written program and make a determination as to the initial exposure levels to be included in the project HASP for exposure reduction if there is a determination that employee exposures may exceed the OSHA Action Level. The HASP will be reviewed at least annually. The program must include:
 - The locations and operations of potential lead exposure
 - Means to achieve compliance
 - Available air monitoring data or industrial hygiene estimates of airborne concentrations
 - Schedule for implementing control procedures
 - Exposure control processes
 - Medical surveillance requirements
 - Training requirements
 - Emergency response
 - The written program must list the corrective actions that will be taken to reduce employee exposure to at or below the OSHA Action Level:
 - identify regulated areas/tasks and the operations where lead may be encountered;

- the specific means to achieve compliance with OSHA, client, and other applicable requirements;
 - engineering controls;
 - revised work practices;
 - respiratory protection and protective clothing; and
 - schedule of development and implementation.
- *Spills and Emergencies:*

An emergency is any occurrence which may result in an unexpected significant release of lead or lead-containing compounds that may result in a significant inhalation. After an emergency, appropriate monitoring must be conducted to assure the ambient lead levels are back to normal; and conduct appropriate medical surveillance for affected employee(s).

- *Respiratory Protection and Personal Protective Equipment:*
 - Respirators shall be worn, maintained and managed in accordance with the OSHA standard, 29 CFR 1910.134 and ARCADIS SOP ARC HSGE017 – Respiratory Protection. In addition, any client requirements on project sites will be followed.
 - Respiratory protection will be worn in all areas as determined in the project HASP and per client requirements. Respirators will be at a minimum, full-face air purifying respirators equipped with HEPA filters.
 - Protective clothing will be worn per the requirements of the client or the project HASP and will include at a minimum at or above the OSHA Action Level:
 - Coveralls
 - Gloves
 - Hood
 - Boots and boot covers
 - Face shield (depending on operation)
 - Goggles

- *Ventilation Systems:*

Where appropriate, ventilation systems will be utilized to control the level of airborne lead per the client and HASP requirements. These ventilation systems will be equipped with HEPA filtration and be maintained to ensure effective collection of the lead particulate. Personnel who maintain these systems and change the filters will be appropriately protected per this policy and procedure to minimize exposure.

- *Personal Hygiene:*

Where lead is present at any level, project personnel handling such media containing lead will wear gloves to minimize exposure of lead to the skin that can then be transferred to the mouth. In all areas where lead is present, personnel will dutifully wash their hands and face before leaving the area to eat, drink, smoke, chew or apply cosmetics. Decontamination and changing facilities will be provided as necessary. In situations as indicated in the project HASP, PPE will be worn to protect the skin from exposure. However, even where PPE is worn, hand and face washing is required.

5.1.8 Medical Surveillance

- Initial medical surveillance is required:
 - If employee personal exposures are reasonably expected to exceed the Action Level on at least 30 calendar days per year; or
 - If employee personal exposures are reasonably expected to exceed the PEL on a least 10 calendar days per year.
- Periodic exams are required on an annual basis for employees who continue to meet the criteria listed above. Annual exams may be discontinued after the exam conducted the year after personal exposures fall below the limits stated above in this section.
- The specific medical exam requirements are explained in detail in ARCADIS SOP ARC HSGE010 - Medical Surveillance. In addition, ARCADIS will work with WorkCare to ensure the proper medical surveillance, testing and notification is completed related to exposure to lead. This includes timing of sampling (e.g., at least every 6 months to each covered employee; at least every two months for each employee whose last blood sampling and analysis indicated a blood lead level at or above 40 ug/100 g of whole blood; and at least monthly during the removal period), treatment if levels are elevated (e.g., temporary removal from the site), and employee notification (i.e., within 5 days of levels are not acceptable).
- The physician must be supplied a copy of the OSHA lead regulation 29 CFR 1910.1025 and a description of the employee's lead exposure.
- For employees exposed to lead from an emergency, ARCADIS will immediately call WorkCare and follow all instructions for treatment and testing

5.1.9 Training

- Initial lead training is required for all employees assigned to a work area suspected or known to contain lead. This training can be accomplished at the project orientation prior to the initiation of site work.

- Annual lead training is required at a minimum for all employees actually or potentially exposed to greater than the Action Level.
- Initial and annual training shall consist of:
 - The operations that involve lead exposure.
 - The methods/observations that can be used to detect the presence or release of lead
 - The physical and health hazards of lead.
 - Methods used to protect against the hazards of lead including PPE and respiratory protection.
 - The proper use of personal protective equipment in emergency situations.
 - The meaning of a regulated area and how such are demarcated.
 - A review of the applicable standard and where copies can be found.
 - An explanation of the medical surveillance program and an employee's right to access medical and exposure records.

6.0 References

- OSHA 29 CFR 1910.1025 – Lead
- OSHA 29 CFR 1926.62 – Lead
- ACGIH 2006 TLVs and BEIs – Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices
- ARCADIS Medical Surveillance SOP – ARC HSGE006
- ARCADIS Respiratory Protection SOP – ARC HSGE017

7.0 Records

- All exposure, medical, and training records shall be kept for 40 years or at least 20 years past the last date of employment.
- All exposure and medical records shall be made available to appropriate regulatory agencies upon written request.
- Employees who have been monitored for lead exposure shall be notified of the monitoring results within 15 working days of receipt of these results; a written request is not required

ARCADIS

Appendix E

Correspondence



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604

REPLY TO THE ATTENTION OF: SR-6J

March 30, 2009

Frank A. Blaha
Chief, Environmental Compliance
United States Coast Guard
Civil Engineering Unit
1240 East Ninth Street, Room 2179
Cleveland, OH 44199-2060

Re: Draft Removal Action Work Plan
U.S. Coast Guard Old Station Ludington
Ludington, MI
Arcadis, Inc., March 9, 2009
Submitted by your March 17, 2009 letter.

Dear Mr. Blaha:

U.S. EPA has completed its review of the Draft Removal Action Work Plan for the Old Station Ludington site.

We noted previously in our comments on the draft EE/CA that the laboratory switched methods for lead analysis from 7420 to 6010B due to a lack of necessary instrumentation. If the Coast Guard intends to use 6010B for site closure samples at Ludington or any other site, please be sure that the QAPP is amended (including data acceptance and flagging criteria) prior to mobilizing for field work.

U.S. EPA has no additional comments, and recommends that the Work Plan be finalized.

If you have any questions I can be reached at 312 886-4843.

Sincerely,

A handwritten signature in black ink, which appears to read "W. Owen Thompson".

W. Owen Thompson
Remedial Project Manager
Superfund Remedial Response Section Six